

STEVNS KLINT



Foreword

As part of the Danish implementation of the UNESCO World Heritage Convention, the Heritage Agency of Denmark decided in January 2009 to include Stevns Klint on the Danish Tentative List for sites for future consideration as World Heritage sites.

The Stevns Klint area is a significant Earth science site that includes a theme not yet present on the World Heritage List: Global mass extinction associated with an asteroid impact. The scenic Stevns Klint site is outstanding between 500 sites around the world comprising the spectacular mass extinction event at the Cretaceous–Tertiary boundary because of the long and accessible exposures of the complete boundary section and because of its long and continued importance to the scientific studies.

Since joining UNESCO, the Danish Government has been working to affirm its support for the World Heritage Convention, and we are pleased to be able to nominate this natural site for inclusion in the prominent list.

Local people and authorities in the Stevns area have participated in the successful development, protection and designation of the Stevns Klint site in qualifying cooperation with the national level.

We therefore fully support the nomination of Stevns Klint for World Heritage status.



Anne Mette Rahbek
Director
Heritage Agency of Denmark
Denmark



Poul Arne Nielsen
Mayor
Stevns Municipality
Denmark

January 2012





Preface

Achievement of long-term protection and positive management of the nominated site is a central concern of the proposal.

Work towards this nomination has involved active local, national and international consultation, and the principles and priorities for management have been established through thorough debate and investigation. A management plan approved by the local authorities outlines the future management of the nominated area. The nomination document is prepared with the assistance and advice of many people and institutions.

We are delighted to commend this nomination to the World Heritage Committee of UNESCO.

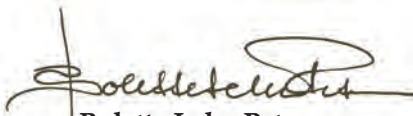
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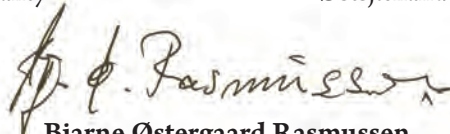
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January 2012



stevns kommune



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Nomination of

STEVNS KLINT

for inclusion in the World Heritage List

Tove Damholt and Finn Surlyk



NOMINATION OF STEVNS KLINT

The present project has received financial support from the Heritage Agency of Denmark, the Geological Survey of Denmark and Greenland and Nordea-fonden.



NORDEA
FONDEN

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Denmark





Executive Summary

State Party

Denmark.

State, Province or Region

Stevns Municipality.

Name of Property

Stevns Klint.

Geographical Co-ordinates to the Nearest Second

N 55° 16' 02" E 12° 25' 24"

Textual Description of the Boundaries of the Nominated Property

The nominated property comprises the 15 km long and up to 41 m high rugged coastal cliff of Stevns Klint, Denmark, encompassing the geological formations covering the Cretaceous–Tertiary mass extinction event. The nominated property covers 50 ha including the exposure of Cretaceous and Tertiary strata within the coastal cliff, on the seafloor, in a tunnel system, and in abandoned quarries.

The boundary of the nominated property accommodates the natural processes of coastal erosion and as the cliff face migrates landward so too does the nominated property boundaries. The boundaries of the cliff are defined by topographic features visible in the landscape and therefore ensures that they are clearly identifiable on the ground and ultimately useful for site management. A buffer zone is outlined following boundaries of existing areas of legal protection. Landwards, the buffer zone follows a national 300 m coastal protection zone and seawards it follows the boundary of an area included in the European Natura 2000 network of protected areas.

Justification Statement of Outstanding Universal Value

Stevns Klint (klint = cliff) is a 15 km long scenic coastal cliff one hour drive south of the Danish capital Copenhagen. Stevns Klint illustrates the most spectacular global mass extinction event in the history of Earth: The Cretaceous–Tertiary boundary. The mass extinction that occurred 65 million years ago is particularly spectacular due to its association with an asteroid impact and because it marks the extinction of more than half of all species, including land-living dinosaurs and large marine reptiles.

Stevns Klint forms the best exposed Cretaceous–Tertiary boundary section in the world with the exceptional boundary layer being easily recognisable immediately beneath a pronounced topographic overhang, which separates the underlying soft Cretaceous chalk from the overlying, harder Tertiary limestone. The thin black boundary clay layer found in the up to 40 m high, white cliff clearly marks the fall in primary production and makes the exceptional boundary layer visible even to the inexperienced eye.

Criterion viii: Stevns Klint is an outstanding example representing a major stage in Earth's history and the record of life: The mass extinction at the Cretaceous–Tertiary boundary. An example of the major changes caused by an asteroid impact is presently not found on the World Heritage List and based on the combination of quality of exposure, fossil diversity, and scientific impact the Stevns Klint site stands out from the more than 500 registered localities globally comprising the spectacular catastrophe at the Cretaceous–Tertiary boundary.

Map of the nominated Stevns Klint area and the surrounding region, showing the boundaries of the nominated area and the buffer zones. The location of the nominated area in Denmark and the World is also shown.

NORTHERN HEMISPHERE



DENMARK





NOMINATION OF STEVNS KLINT

The nominated site has played a significant role in the international study of the causes of mass extinction and the effect of extraterrestrial impact on life on Earth as it was among the original study localities that first led scientists to the hypothesis of an asteroid impact as a cause for mass extinction and is thus of high value for understanding of key evolutionary problems.

The key to the integrity of Stevns Klint lies in the completeness of the boundary section, the good preservation of rich fossil assemblages, and in the high quality of the outstanding exposure of high permanency and great lateral extent. The site boundaries are defined to encompass the extent of the continuous exposure that is of utmost importance to reveal any variation in depositional environment and thus to allow filtering of local signals recorded in the environment from the global signal of mass extinction. The intense scientific interest adds to the integrity as the more than 200 scientific papers provide a high degree of documentation of the site.

The legal protection of the nominated area and its buffer zone is adequate, and national and municipal legislation accords protection of future exposures in a buffer zone landward of the property. The property is well managed and resourced, with a comprehensive management plan in place and resources for its implementation. Key management issues include presenting the geological site and its significance, and managing the expected increase in number of visitors to the property. Natural wave erosion secures high quality exposure for at least 20,000 years.

Criteria under which the Property is Nominated

Stevns Klint is proposed to be inscribed under the criteria (viii) of Paragraph 77 of the Operational Guidelines for the Implementation of the World Heritage Convention (2008), stating that the nominated properties shall:

“Be outstanding examples representing major stages of earth’s history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiogeographic features”.

An example of the major changes caused by an asteroid impact is presently not found on the World Heritage List nor is a complete Cretaceous–Tertiary boundary section. Stevns Klint is proposed to be inscribed as it is an outstanding example representing a major stage in Earth’s history and the record of life: The mass extinction at the Cretaceous–Tertiary boundary.

Name and Contact Information of Official Local Institution

The official local institution responsible for the management of the nominated property is Stevns Municipality.

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STEVNSKLINT
STEVNSKLINT

Table of Contents

Foreword	3	4.b (iii) Natural Disasters and Risk Preparedness ...	93
Preface	5	4.b (iv) Visitor/Tourism Pressures	94
Executive Summary	10	4.b (v) Number of Inhabitants Within the Property and the Buffer Zone	95
Table of Contents	13	5. Protection and Management of the Property	97
1. Identification of the Property	14	5.a Ownership	97
1.a Country	14	5.b Protective Designation	97
1.b State, Province or Region	14	5.c Means of Implementing Protective Measures	99
1.c Name of Property	14	5.d Existing Plans Related to Municipality and Region in which the Proposed Property is Located	104
1.d Geographical Coordinates to the Nearest Second	14	5.e Property Management Plan	105
1.e Maps and Plans showing the Boundaries of the Nominated Property and Buffer Zone	14	5.f Sources and Levels of Finance	107
1.f Area of Nominated Property and Proposed Buffer Zone	16	5.g Sources of Expertise and Training in Conservation and Management Techniques	107
2. Description	19	5.h Visitor Facilities and Statistics	108
2.a Description of Property	19	5.i Policies and Programmes Related to the Presentation and Promotion of the Property ...	109
Geology	19	5.j Staffing Levels	110
The Importance of Stevns Klint in the History of Science	38	6. Monitoring	113
Post-Danian Uplift and Erosion	45	6.a Key Indicators for Measuring State of Conservation	113
Cliff Formation	45	Geology	113
Wildlife Interests of the Nominated Site	46	Nature	114
The Extent and Method of Exploitation	56	Tourism	114
2.b History and Development	57	6.b Administrative Arrangements for Monitoring Property	114
History of Exploitation	57	6.c Results of Previous Reporting Exercises	115
The Military History of Stevns Klint	62	7. Documentation	117
Stevns Klint and the Sea	64	7.a Photographs, Slides, Image Inventory and Author- ization Table and other Audiovisual Materials ..	117
History of Tourism	66	7.b Texts Relating to Protective Designation	117
3. Justification for Inscription	69	7.c Form and Date of Most Recent Records or Inventory of Property	117
3.a Criteria under which Inscription is Proposed (and Justification for Inscription under these Criteria) .	69	7.d Address where Inventory, Records and Archives are Held	117
3.b Proposed Statement of Outstanding Universal Value	72	7.e Bibliography	117
3.c Comparative Analysis (Including State of Conservation of Similar Properties)	73	8. Contact Information of Responsible Authorities ..	125
Prerequisites for Cretaceous–Tertiary Boundary Sections	73	8.a Preparer	125
Comparison and Evaluation of the Cretaceous–Tertiary Boundary Sites	77	8.b Official Local Institution	125
3.d Integrity	85	8.c Other Local Institutions	125
The Extent to which the Property Includes All Elements Necessary to Express its Outstanding Universal Value	85	8.d Official Web Address	125
The Site Boundaries	86	9. Signature on Behalf of the State Party	127
The Extent to which the Property is Affected by Human Activities	89	Citations by Section	128
4. State of Conservation and Factors Affecting the Property	91	Acknowledgements	132
4.a Present State of Conservation	91	Appendix 1: Maps	134
4.b Factors Affecting the Property	92	Appendix 2: Legislation	139
4.b (i) Development Pressures	92	Appendix 3: Inventory of Property	144
4.b (ii) Environmental Pressures	93	Appendix 4: Management Plan	In separate volume
		Appendix 5: Erosion Analysis	In separate volume
		Appendix 6: Comparative Analysis ..	In separate volume

1. Identification of the Property



15'



1.a Country Denmark.

1.b State, Province or Region

Denmark, Stevns Municipality.

1.c Name of Property

Stevns Klint.

1.d Geographical Coordinates to the Nearest Second

The centre of the nominated area is situated at the following coordinates: N 55° 16' 02" E 12° 25' 24".

1.e Maps and Plans showing the Boundaries of the Nominated Property and Buffer Zone

The nominated property comprises 15 km of the rugged coastal cliffs of Stevns Klint, Denmark, encompassing the geological formations covering the Cretaceous–Tertiary mass extinction event. The nominated property includes the exposure of Cretaceous and Tertiary strata within the coastal cliff, on the seafloor, in a tunnel system, and in abandoned quarries (Fig. 1 and Appendix 1).

NOMINATION OF STEVNS KLINT





NOMINATION OF STEVNS KLINT

Due to the continuous erosion from the sea, the profile of the cliff is constantly changing and kept fresh and well exposed. The boundary of the nominated property accommodates the natural processes of coastal erosion and as the cliff face migrates landward so too does the nominated property boundaries. The boundary of the cliff is defined by topographic features visible in the landscape and therefore ensures that they are clearly identifiable on the ground and ultimately useful for site management.

The buffer zone is defined with the primary purpose of achieving protection and management of the nominated property. The buffer zone is outlined following boundaries of existing areas of legal protection. Landwards, the buffer zone follows a national 300 m coastal

protection zone and seawards, it generally follows the boundary of an area included in the European Natura 2000 network of protected areas (Fig. 2).

Maps showing the location and boundaries of the nominated property and buffer zone are included in Figs 1 and 2, and in Appendix 1.

1.f Area of Nominated Property and Proposed Buffer Zone

Areal	50 ha
Land	41 ha
Seafloor	9 ha
Buffer zone	4136 ha
Land	471 ha
Seafloor	3665 ha
Total	4186 ha

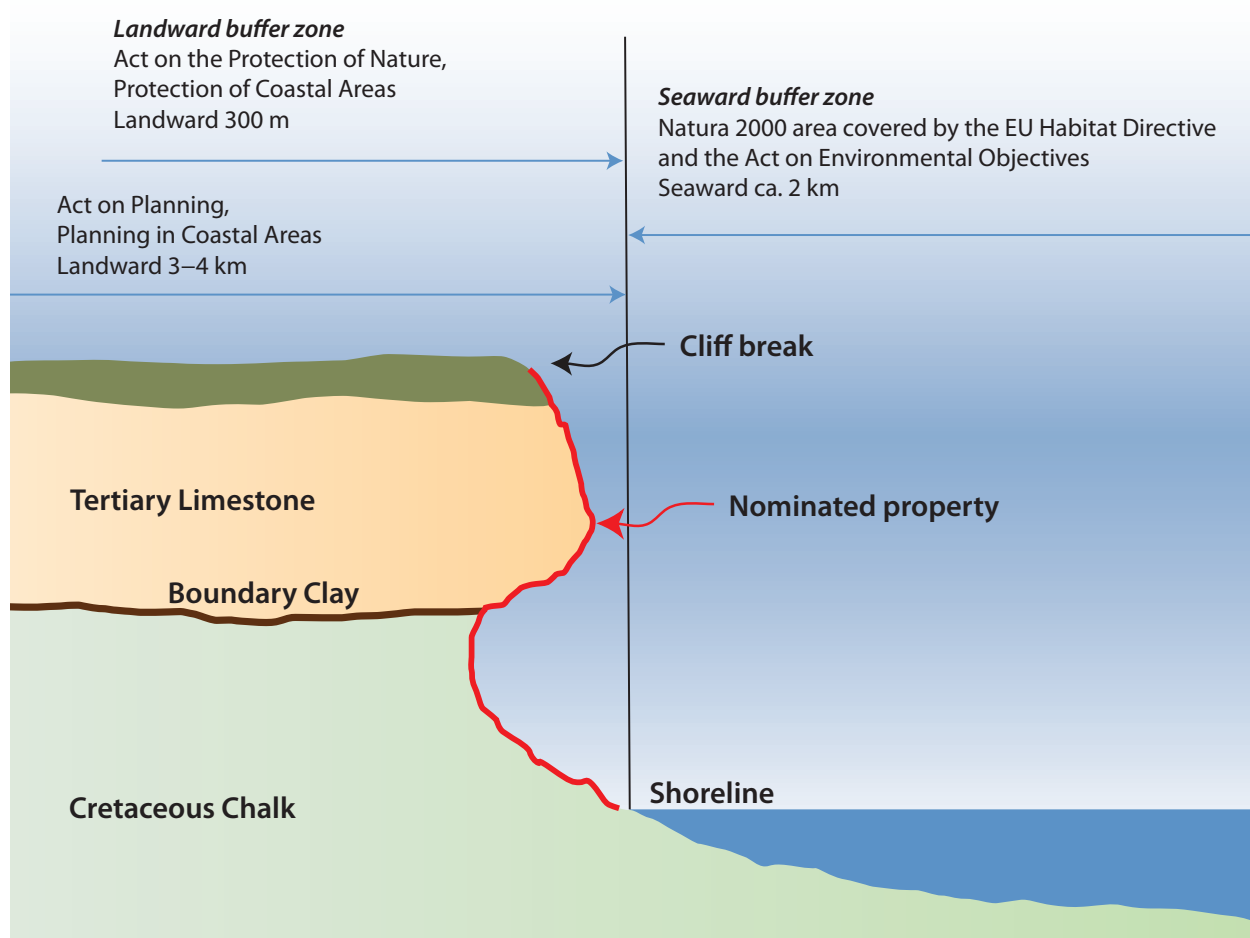


Figure 2. Cross section illustrating the relation between the nominated property, the buffer zone, and legal zones of protection.



Figure 3. The classical Stevns Klint section with the boundary (arrow) easily recognisable immediately beneath the pronounced overhang.



2. Description



2.a Description of Property

Geology

The Cretaceous–Tertiary Boundary

Stevns Klint (klint = cliff) is a scenic coastal cliff located about 45 km south of the Danish capital, Copenhagen, on the east coast of the Danish island of Sjælland separating the flat landscape of Stevns from the Baltic Sea. The 15 km long and up to 41 m high white coastal cliff offers high quality exposures of the Cretaceous–Tertiary boundary layers.

The Cretaceous–Tertiary boundary marks a severe ecological crisis and mass extinction that put an end to the Mesozoic Era 65.5 million years ago. The Cretaceous–Tertiary mass extinction has been intensely studied and is a subject of huge interest, partly because it includes the extinction of the spectacular non-avian dinosaurs, and partly because of its significant role in the discussion of the possible causes of mass extinctions and the effects of extraterrestrial impact.

Stevns Klint is a classical study locality and arguably the best exposed Cretaceous–Tertiary boundary section in the world with the boundary layer being easily recognisable immediately beneath a pronounced topographic overhang, which separates the underlying soft Cretaceous chalk from the overlying harder Tertiary limestone (Fig. 3) (see Section 3).

The cause of the mass extinction at the Cretaceous–Tertiary boundary has been intensely debated for more than 30 years (Box 1) since the presentation of the hypothesis that an asteroid impact was the major cause of the global crisis (Alvarez *et al.* 1980). Today, there is general agreement that the Earth was struck by an asteroid, which formed the huge crater at Chicxulub in Mexico, causing global effects on life on Earth. The focus of the scientific discussion today is on the effect of the impact taken alone and in combination with other factors such as climate and sea-level change, and the effect of the major volcanic activity recorded in the Deccan Traps of India.

The boundary between the Mesozoic and Cenozoic Eras has been named the Cretaceous–Tertiary (K–T) boundary.

Recently, it has been suggested to use the division of the Tertiary Period into the lower Paleogene and the younger Neogene periods, and therefore the boundary is now often, but not always, referred to as the Cretaceous–Paleogene boundary (K–Pg).

The traditional nomenclature, Cretaceous–Tertiary boundary, is still better known by the media, and general public and will be followed in this nomination material.

To understand the evolutionary trend, including the mass extinction and subsequent recovery of life across the Cretaceous–Tertiary boundary, it is essential to understand the dynamics of deposition across the boundary. At Stevns Klint, these deposits are well known, and changes in primary productivity, temperatures, and sea-level are clearly reflected. Stevns Klint is a classical Cretaceous–Tertiary boundary site documented in more than 200 scientific papers and discussed in many more (Section 7.e).

The Cretaceous at Stevns Klint

The Cretaceous is represented at Stevns Klint by a soft chalk constituting a characteristic example of deposition in the relatively deep epicontinental Chalk Sea that covered most of NW Europe in Late Cretaceous times (Fig. 4).

The Cretaceous chalk deposits exposed at Stevns Klint were deposited in water depths of at least a hundred metres. The precise water depth is difficult to assess and is only constrained by the lack of bottom-dwelling algae or wave-generated structures, indicating depths below the photic zone and below storm wave base.

The chalk is composed of tiny skeletal fragments from unicellular coccolithophorid protists that lived in the uppermost water masses and used sunlight for photo-

BOX 1: THE ASTEROID HYPOTHESIS

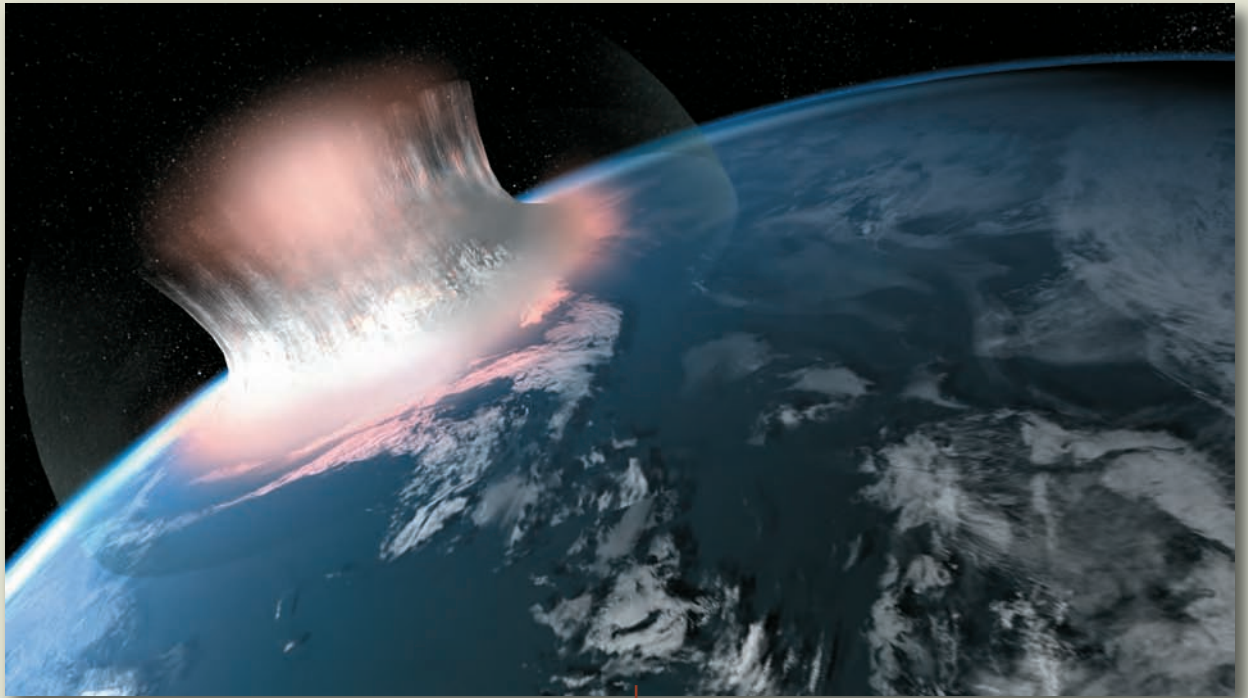


Illustration: Carsten Eggebal Thuesen

In 1980, one of the most important geological papers in the 20th century appeared in *Science*, when Alvarez *et al.* presented the hypothesis that the mass extinction at the Cretaceous–Tertiary boundary was caused by an asteroid impact. Prior to 1980, the biotic and environmental changes across the Cretaceous–Tertiary boundary had been the subject of the efforts of numerous scientists and a range of explanations had been introduced, including global climate change, plate tectonic movements, and sea-level change.

The new asteroid impact hypothesis was based on a study initiated by the American geologist Walter Alvarez who studied the Cretaceous–Tertiary boundary in Gubbio, Italy. There he was looking for a measure to unravel how much time was represented by the boundary clay layer and discussed this question with his father, the Nobel Prize winning physicist Louis Alvarez.

Based on the assumption that the Earth receives a constant amount of extraterrestrial dust Louis Alvarez suggested that they calculated the changes in rate of sedimentation simply by measuring the concentration of extraterrestrial material in samples across the boundary. As a representative for the extraterrestrial material, they chose to measure the relative amount of iridium, a platinum group metal that is rare in the Earth's crust and almost exclusively reaches Earth from space. When they measured the iridium content they got the surprising result that the concentration of iridium in the boundary clay compared to other elements was much higher than expected.

Asteroid impact

Based on the relative iridium enrichments found in the boundary clay, Alvarez *et al.* (1980) calculated that the asteroid that hit Earth at the Cretaceous–Tertiary boundary must have been 10 km in diameter producing a 100–150 m deep crater and forming a dust cloud that encircled the Earth causing prolonged darkness, inhibiting photosynthesis, and causing the global disaster, resulting in the mass extinction. The catastrophic scenario of extraterrestrially triggered mass extinction made the paper highly controversial, resulting in massive scientific debate, and the fact that it included the extinction of dinosaurs made it subject to instant public interest. Although the effect of the impact is still not fully understood, it is documented that the enormous amount of energy released not only caused regional earthquakes and giant tsunamis, but also sent large volumes of dust stemming from both the asteroid and the impact area into the stratosphere where it limited the supply of sunlight to Earth's surface for a substantial period of time, causing a collapse of the base of the marine food chains, and the ecological systems, and thus had fundamental effect on life on Earth.

The question now was whether the enrichment of iridium was a local phenomenon or if they had detected a global phenomenon indicating that the Earth had received large amount of extraterrestrial material at the Cretaceous–Tertiary boundary. To answer this question, Walter Alvarez travelled to Stevns Klint in Denmark to collect a sample of the boundary clay at the classical visitor site at Højerup. Returning to the laboratory, the Alvarez research group discovered to their excitement that the enrichment of iridium at Stevns Klint was even higher than that recorded in Italy (Alvarez 1997).



Photo: Søren Gregersen

Walter Alvarez (to the right) collecting boundary clay at Stevns Klint 1978.

The Stevns Klint sample thus confirmed that the iridium enrichment at the Cretaceous–Tertiary boundary was indeed a global phenomenon and formed the basis for the new theory presented in the Alvarez *et al.* 1980 paper.

The discussion of the cause of the mass extinction was intense in the 1980s and 1990s, and the debate led to heated discussions in scientific papers, meetings and geological gatherings. The catastrophic impact model gained support by the finding of an impact crater in the Yucatán peninsula, Central America, and by the documentation of fragmented, tumbled and disturbed sedimentary blocks in and close to the impact area, indicating catastrophic submarine mass flows or tsunami activity triggered by the impact. The observation of the comet Shoemaker-Levy-9 colliding with Jupiter in 1994 provided a direct observation of a similar extraterrestrial planet impact by an asteroid.

Today, it is generally agreed that Earth experienced an asteroid impact, causing the characteristics of the boundary layer, and including mass extinction at the Cretaceous–Tertiary boundary (e.g. Schulte *et al.* 2010a). The effect and timing of the Deccan Trap volcanism are still debated as is the influence of climate change (Archibald *et al.* 2010; Courtillot and Fluteau 2010; Keller *et al.* 2010; Schulte *et al.* 2010b). Future studies are still needed to shed light on many aspects of the extinction around the Cretaceous–Tertiary boundary, and the nominated Stevns Klint site is a key locality in these studies.

Vulcanism and climate change

The controversial catastrophic asteroid impact hypothesis was opposed by two main alternative models: the gradualist model in which extinction was said to have occurred over long intervals of time as a result of climate and sea-level changes, and the volcanic model explaining the event as a result of intense volcanism in the Deccan Traps, India. Towards the end of the Cretaceous Period, more than 25 million years of relative climatic stability and extraordinary high sea-levels were coming to a halt, inevitably having an effect on life on Earth. Additional climatic changes resulted from the huge volcanic activity reflected by the eruption of the thick basalts of the Deccan Traps in India. The volcanic activity lasted a few million years spanning the boundary and caused the release of sulphur, carbon dioxide and volcanic dust, reducing the amount of sunlight reaching Earth's surface and causing environmental disturbance. It was in this period of climatic instability that the Earth was hit by the large asteroid.



Photo: Omar Ragnason

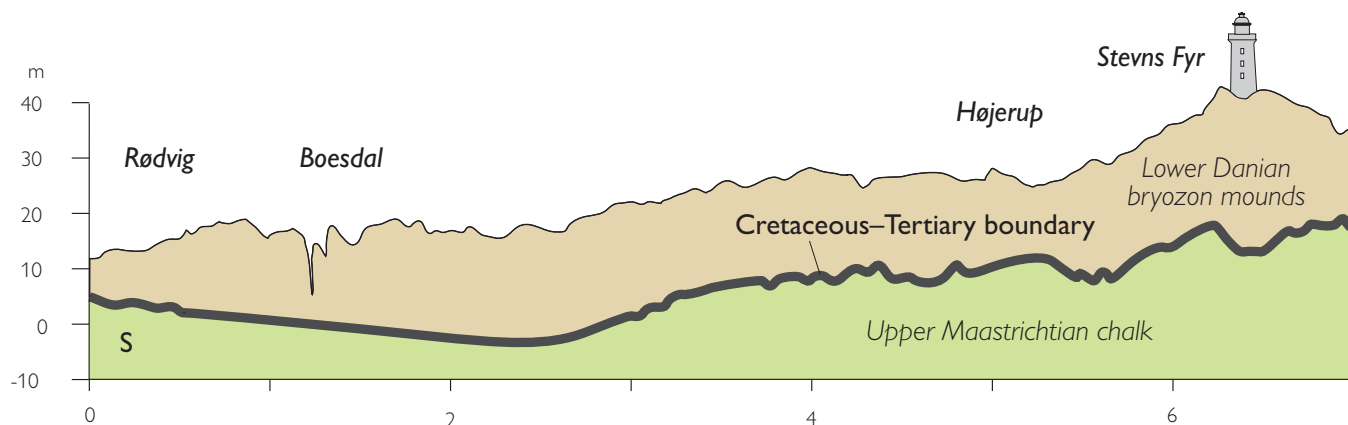
NOMINATION OF STEVNS KLINT



Figure 4. Map showing the extent of the Late Cretaceous sea covering much of NW Europe.

synthesis (Fig. 5). After the death of the coccospheres, the skeletal fragments slowly fell through the water column as fecal pellets from copepods until they reached the seafloor and accumulated into a thick succession of extremely fine-grained sediment.

Chalk is typically an oceanic sediment type, but in Late Cretaceous times when sea-level was much higher than today, this sediment spread out over the flooded continents (Box 2). Northwestern Europe was a region with only limited, local tectonic activity and



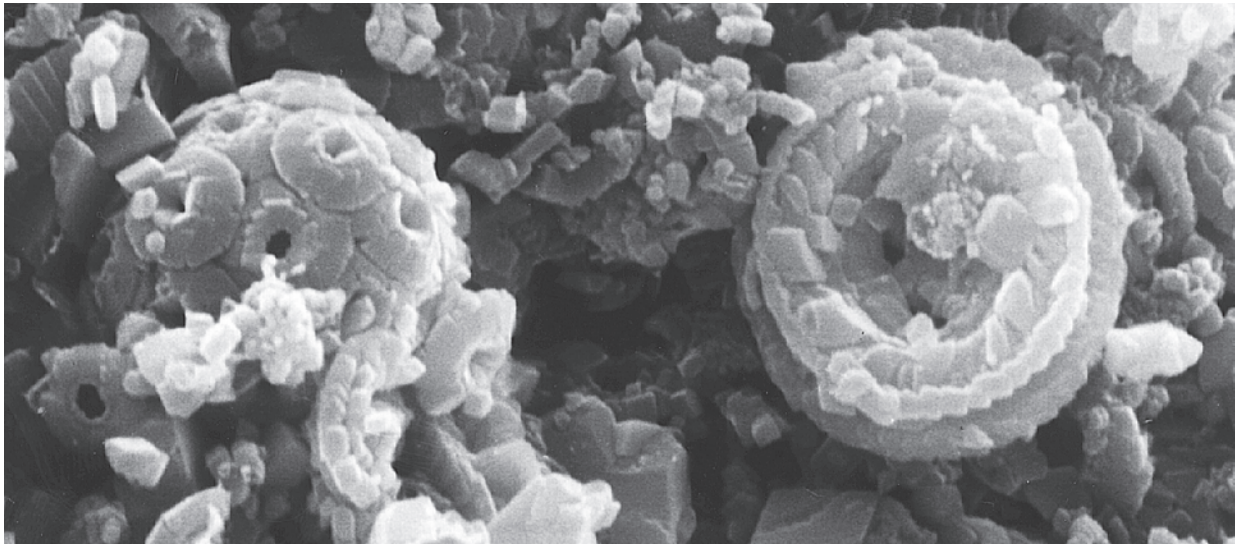


Photo: Peter Frykman

Figure 5. Skeletal fragments of coccolithophorid protists. Enlarged c. 2000 times.

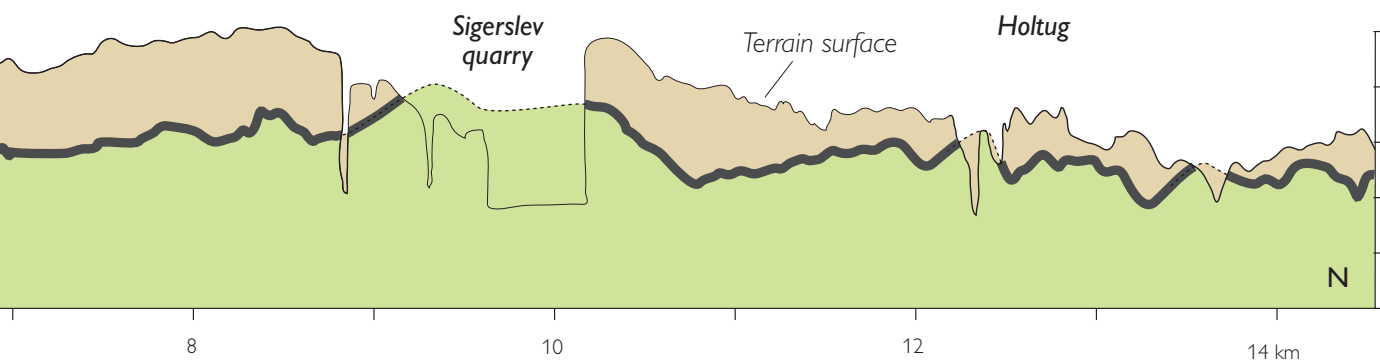
the landmasses surrounding the Chalk Sea were worn down. The combination of arid climate, sparse localised tectonic activity, and worn-down landmasses resulted in a very limited supply of clay that would normally reach the sea through rivers. This explains the purity of the white chalk that is composed basically of pure skeletal fragments and only very small amounts of clay.

At the classical Stevns Klint site at Højerup, located centrally along the cliff, the Cretaceous chalk is visible in the lower half of the cliff below the pronounced overhang of Lower Tertiary, Danian limestone, marking the top of the Cretaceous deposits and its boundary with the overlying Tertiary deposits (Fig. 3).

Along the length of the cliff, the position of the boundary varies from about five metres below the present-day sealevel in the southern part to about 35 m above the present-day sealevel in the northern part of the cliff, forming a topographic relief of the boundary layer of more than 40 m (Fig. 6). The thickest Cretaceous chalk succession is therefore exposed in the northern part of the cliff.

The large-scale structure depicted by the position of the boundary has long been recognised and has traditionally been considered to be the result of younger, Tertiary tectonic folding. New investigations based on subsurface seismic data show that there is no evidence for tectonic folding and the relief is a primary struc-

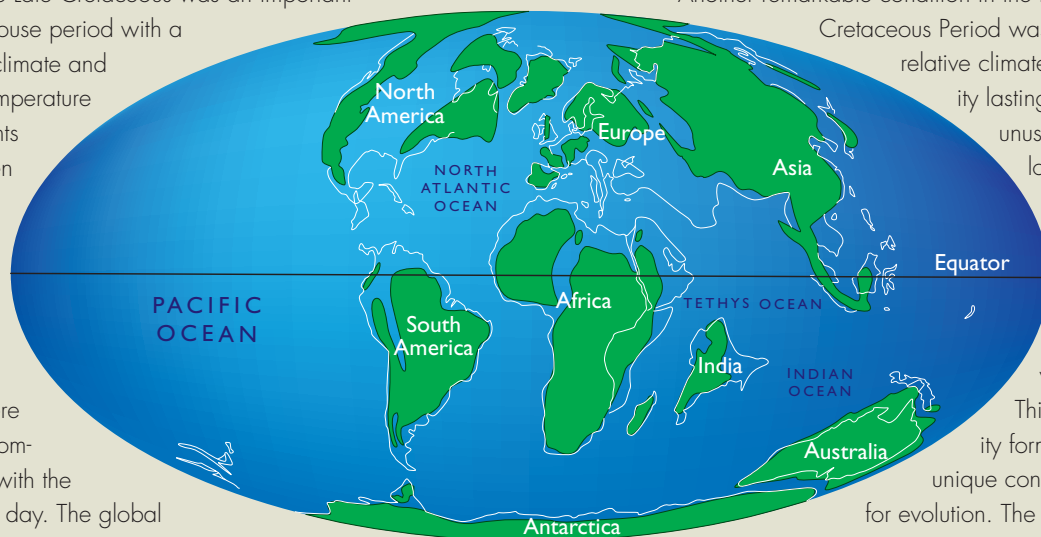
Figure 6. Stevns Klint profile illustrating the topography of the boundary layer (black line).





BOX 2: THE LATE CRETACEOUS

The mass extinction at the Cretaceous–Tertiary boundary took place at the end of a unique period in the history of life. The Late Cretaceous was an important greenhouse period with a warm climate and with temperature gradients between the equator and the poles that were small compared with the present day. The global sealevel was high, probably more than a hundred metres above the present-day sealevel, and reached one of its highest stands during the Phanerozoic. The high sea-level resulted in flooding of extensive low-lying continental areas and formed a deep epicontinental sea that covered most of northwestern Europe, including the area of present-day Denmark.



These extraordinary conditions led to the development of a unique habitat, the Chalk Sea.

Another remarkable condition in the Late Cretaceous Period was the relative climate stability lasting for the unusually long period of more than 30 million years. This stability formed unique conditions for evolution. The long stable period resulted in the continued deposition of thick successions of uniform chalk, and in the development of a highly specialised marine invertebrate biota as found in chalk deposits around the world, including the nominated area.

ture, which mimics the topography of the Late Cretaceous sea floor (Lykke-Andersen and Surlyk 2004). The lower part of the chalk exposed in the northern part of Stevns Klint shows irregular low-amplitude mounded bedding outlined by thin layers of nodular flint (Fig. 7). The bedding illustrates that the local seafloor topography was formed by a system of gentle, large-scale structures, including relatively long mounds with smaller mounds superimposed, forming structures on a broad range of scales (Anderskov *et al.* 2007).

The chalk deposits of the large-scale mounds are generally rich in macrofossils, representing a highly diverse marine bottom-dwelling fauna dominated by bryozoans, bivalves, brachiopods, echinoids, serpulids, solitary corals and sponges. Gastropods were also an

important group, but because of dissolution of the shells during early burial, they have only been preserved in certain early hardened layers.

A rich fauna is characteristic for the Chalk Sea, which covered most of northwestern and central Europe for more than 30 million years and represented a unique marine habitat. The exceptionally long period of stable marine environment led to the development of a highly specialised marine fauna (Fig. 8). The species diversity at Stevns Klint is very high for nanno-, micro-, meso- and macrofossils, and most marine fossil groups are represented. In total, the exposed Upper Cretaceous chalk at Stevns Klint contains more than 450 species of macrofossils and in addition hundreds of species of nanno- and microfossils.



Photo: Jakob Laurrup

Figure 7. Layers of nodular flint (marked with arrows) outline irregular mounds in the Cretaceous chalk. The cliff is 22 m high. The mounds were formed on the seafloor by a complex interplay of pelagic sedimentation, bottom currents, and the life of bottom-dwelling invertebrates.

Above the mounded lower part of the succession, the chalk shows more flat-lying, almost horizontal bedding and is poor in flint. This chalk is poor in benthos but has abundant *Zoophycos* trace fossils, a form that is typical of deep-water deposits. This chalk was deposited in deeper water under more quiet conditions with no or very low-velocity bottom currents (Anderskov *et al.* 2007).

The end of the Cretaceous

After the period of deeper water sedimentation, more than 30 million years of chalk deposition was terminated towards the end of the Cretaceous (Fig. 9). At Stevns Klint, the deep-water chalk is capped by two incipient hardgrounds, reflecting a fall in sea-level estimated to many tens of metres possibly even as high as 50–100 m (Schmitz *et al.* 1992; Surlyk 1997), most probably reflecting a major global fall in sealevel (Haq *et al.* 1987) (Fig. 9). The incipient hardgrounds formed as a result of a stop in sedimentation,

resulting in an early hardening of the seafloor and the development below the hardground of a characteristic nodular flint layer, which can be followed as a marker bed along the cliff 4–5 m below the Cretaceous–Tertiary boundary.

The sea-level fall marked by the incipient hardgrounds had a clear effect on life on the seafloor which was still below the photic zone, precluding much of the benthic

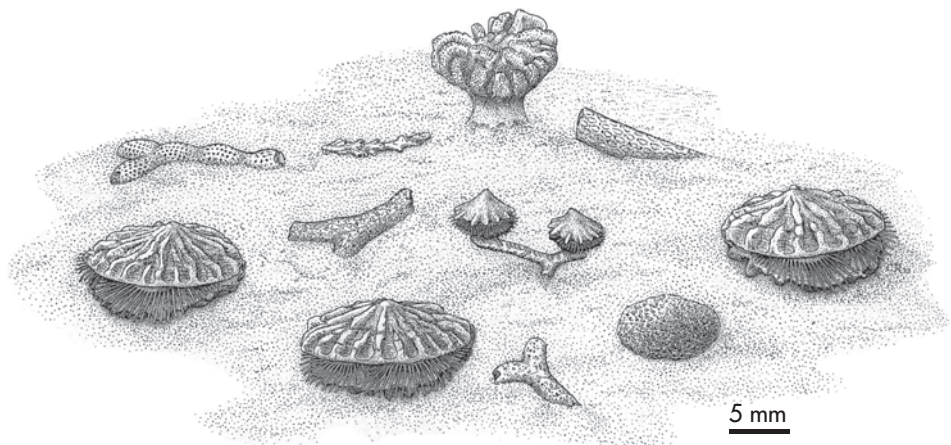


Figure 8. The brachiopod *Isocrania costata* lying free on the chalk sea floor. (From Surlyk 1973).

Stevns Klint is an outstanding example representing a major stage in the Earth's history and the record of life.

TERTIARY LIMESTONE

At the boundary more than half of all living Cretaceous species became extinct including land-living dinosaurs and large marine reptiles.

After the mass extinction a full ecosystem gradually evolved including new species.

CRETACEOUS CHALK

Cretaceous–Tertiary 65 Million Years Ago

Incipient hardgrounds.

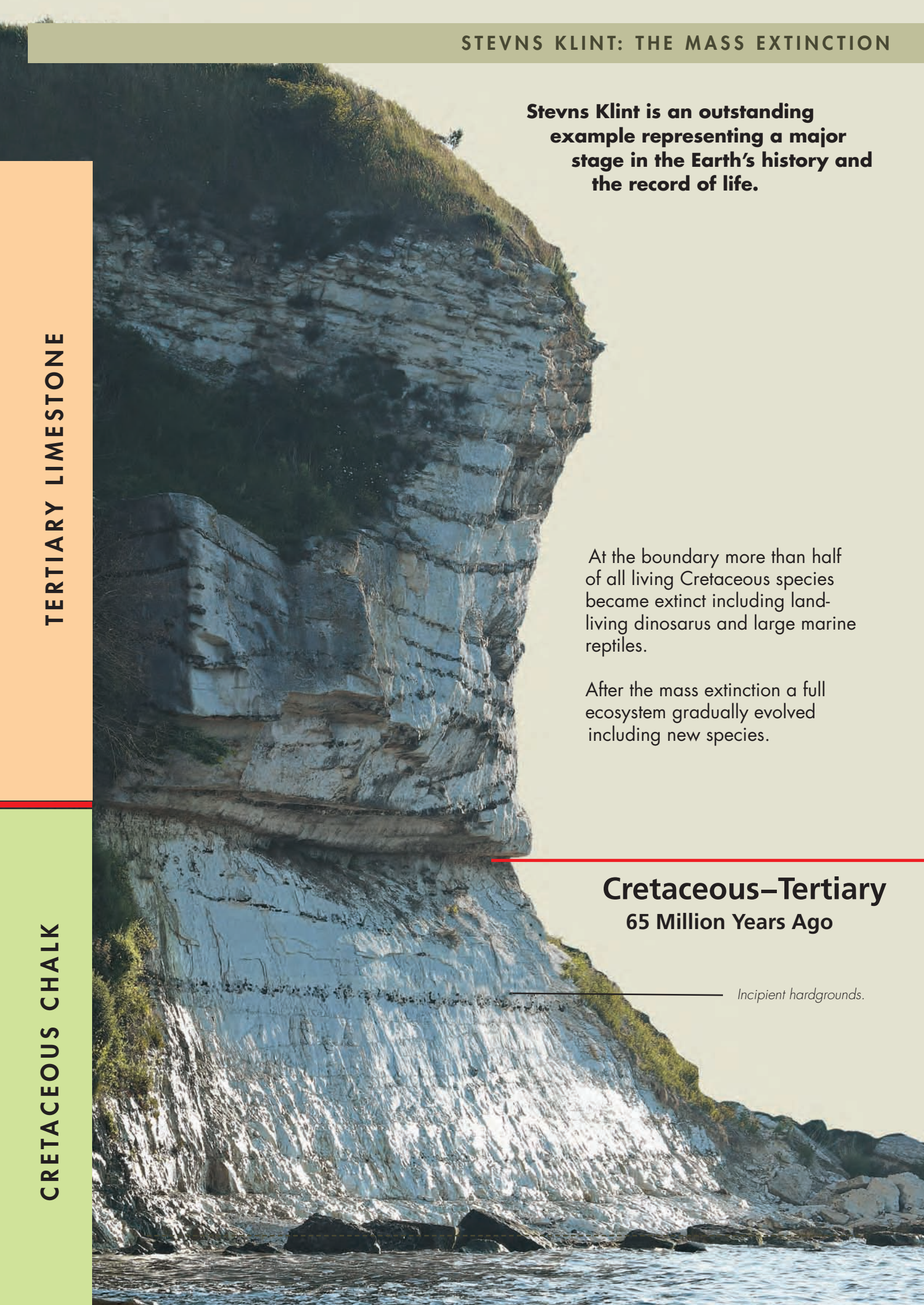




Photo: Finn Surlyk

Scientists, schools and tourists visit Stevns Klint to study the boundary section. More than 200 scientific papers are published since 1759. Most of them after the asteroid hypothesis was first published in 1980.



Illustration: Carsten Eggstad Thuesen

Towards the Cretaceous—Tertiary boundary major sea-level fall, climate changes and volcanic activity affected life on Earth. It was in this period of instability that the Earth was hit by an asteroid.



Photo: Thomas Hansen

Gastropod exemplifying species evolved after the mass extinction event.



Photo: Jakob Laurrup

The thin, dark boundary clay layer in the 40 m high white cliff marks the global mass extinction event.

Boundary



Photo: Søren Lennart Jakobsen

The ammonites are considered to have become extinct at the boundary. However, at Stevns Klint single ammonites have been recorded above the boundary.



Illustration: Carsten Eggstad Thuesen

The large mosasaur became extinct at the boundary.

Fig. 9: The Cretaceous—Tertiary boundary section at Stevns Klint. Incipient hardgrounds 4–5 meters below the boundary reflect a fall in sea-level.



Photos: Jakob Laurrup

Figure 10. The boundary clay at Stevns Klint.

life; however, the seafloor was subsequently colonised by bryozoans, small filter feeding, colonial invertebrate animals. The bryozoans became abundant and grew to form small mounds on the seafloor (Larsen and Håkansson 2000). The seafloor thus had a mounded topography with series of crests and troughs forming mounds about 35 m wide and about one metre high.

The interval of bryozoan mounds between the hardgrounds and the Cretaceous–Tertiary boundary is up to 4.5 m thick but thins gradually towards the north and has almost wedged out in the northern part of the cliff, probably due to a combination of erosion and reduced sedimentation.

The Cretaceous–Tertiary boundary clay at Stevns Klint

The Cretaceous–Tertiary boundary layer at Stevns Klint is an excellent example of a boundary site located distally to the impact crater, which illustrates the glo-

bal effect of the impact (e.g. Schulte *et al.* 2010a). The boundary clay at Stevns Klint consists of a thin clay bed, displaying the characteristic elements of the global mass-extinction event and is clearly visible even to the inexperienced eye (Figs 9, 10).

The distinct dark clay bed marking the Cretaceous–Tertiary boundary is easily identified as it is the only clay layer in the more than 55 m thick succession of white chalk and limestone exposed in the cliff, and because it occurs immediately beneath a pronounced overhang, separating the soft Cretaceous chalk from the overlying harder Lower Tertiary, Danian limestone.

The boundary clay lies in a series of shallow troughs between the gentle mounds of the end-Cretaceous seafloor, and more than 230 troughs have been mapped out along the cliff (Surlyk *et al.* 2006) (Appendix 3.2). The boundary clay is typically up to about 10 cm thick, but at a single locality in the northern part of the cliff, it reaches up to about 30 cm.

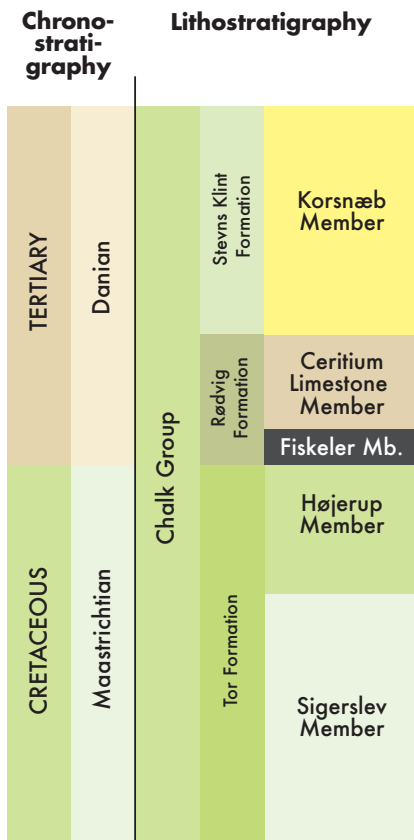


Figure 11. The Stratigraphy of Stevns Klint. From Surlyk, Damholt and Bjerager (2006)

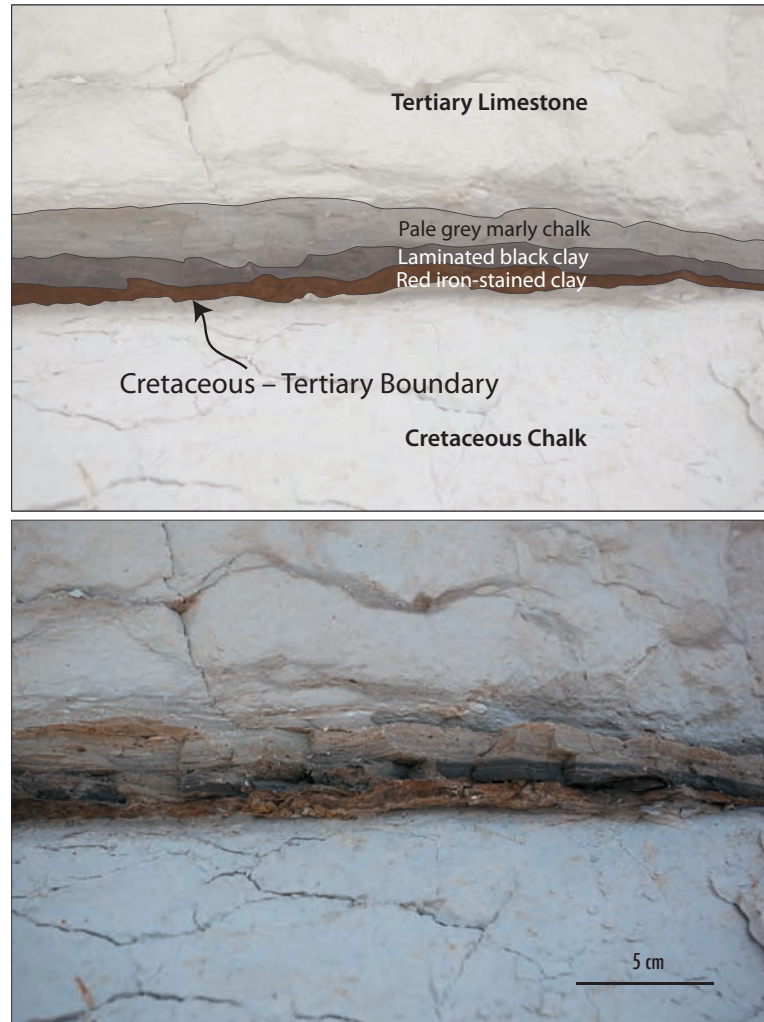


Figure 12. Subdivisions of the boundary clay at Stevns Klint.

At Stevns Klint, the boundary clay has traditionally been named *Fiskeler* (Fish Clay) because of the scattered presence of tiny fish scales. This traditional name is retained today and has recently been formalised as a lithostratigraphic member, the Fiskeler Member (Fig. 11).

The boundary clay records an abrupt stop in carbonate production of nanno-, micro- and microfossil skeletons and indicates a marked fall in primary productivity (Keller *et al.* 1993; Corfield 1994; Hart *et al.* 2004, 2005). This abrupt stop in production has been recorded globally and characterises the Cretaceous – Tertiary boundary.

The boundary clay is subdivided into a number of thin units (Surlyk *et al.* 2006) which are remarkably persist-

ent along the length of the cliff and are similar to subdivisions recognised in boundary sections in other parts of the world (Romein and Smit 1981; Schmitz 1988; Schmitz *et al.* 1988; Hart *et al.* 2005) (Fig. 12).

The base of the boundary clay is represented by red iron-stained clay (5 mm thick). The reddish layer has been recognised in other parts of the world and is sometimes referred to as the impact layer because of the impact-derived content. The presence of an enrichment of iridium and other platinum group elements, shocked quartz, and tektite glass in the boundary layer compared to the normal background level has been intensely studied, and today, there is general

NOMINATION OF STEVNS KLINT



Photo: Peter Werner/Moors

Figure 13. Danian bryozoan mounds at Stevns Klint. The outline of the flint bands show that the southern flanks of the mounds were steeper than the more gentle northern flanks and that the beds on the southern flanks were thicker than on the northern flanks. The shape of the mounds reflects the differences in growth of the bryozoans where nutrient-rich currents from the south favoured bryozoan growth on the southern flanks.

agreement that the boundary layer has an impact-derived signature.

At Stevns Klint, the red layer has one of the highest iridium anomalies found at any boundary site, and is enriched in rare elements such as Ni, Co, Cr, Zn, Cu, As, and Sb, and contains minor amounts of shocked quartz (Bohor *et al.* 1987; Schmitz 1990). Recently, tiny fragments of impact-derived glass have been documented, showing that the clay mineral smectite of the reddish layer is derived from altered glass (Bauluz *et al.* 2000). The reddish layer at Stevns Klint also has a high content of small spherules similar to spherules in the boundary clay worldwide (Hart *et al.* 2005).

The red layer is overlain by up to 5 cm of laminated black clay with a high content of organic carbon and a lack of bioturbation, indicating an absence of life on the seafloor at the time of deposition. The black lami-

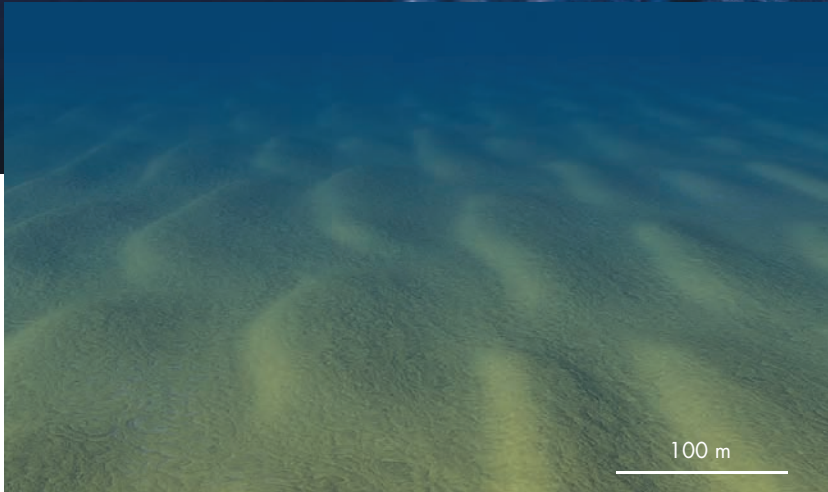
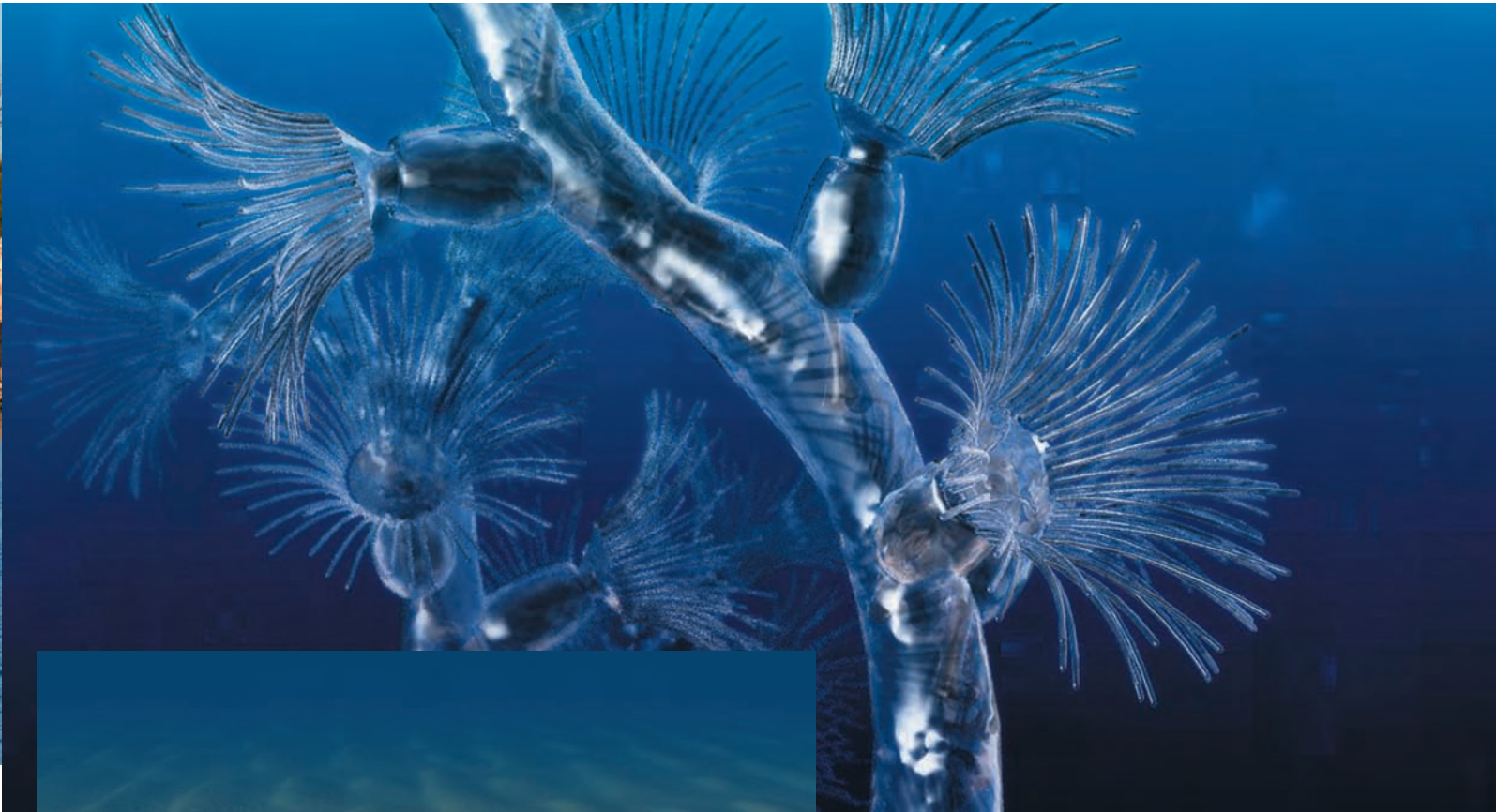
nated clay is overlain by pale grey to white marly chalk that becomes more carbonate-rich upwards and passes gradually into the overlying Cerithium Limestone Member, indicating the renewed onset of primary carbonate production (Fig. 12).

The Tertiary at Stevns Klint

The lowest part of the Tertiary Period, the Danian, is represented by large bryozoan limestone mounds outlined by thick black flint bands, which illustrate the dimensions, geometry, and architecture of one of the finest, ancient cool-water carbonate mound complexes in the world (Fig. 13).

Between the boundary clay and the prominent bryozoan mounds is a thin limestone, the Cerithium Limestone Member. A prominent erosional surface formed by an early hardening of the seafloor truncates the top of the limestone and the intervening crests of the end-

2. DESCRIPTION



Bryozoans are colonial aquatic invertebrate animals. Each individual in the colony, called a zooid, is typically about 0.5 mm long. The bryozoans are filter feeders that sieve food particles out of the water using retractable tentacles placed on a lophophore. The bryozoans grow to form 5–10 m high mounds on the sea floor (illustration inserted).

Illustrations: Carsten E. Thomsen and Stefan Seifert

Cretaceous bryozoan mounds. The erosion and hardening is probably related to a regional or global event. The early hardening has resulted in a detailed preservation of the otherwise dissolved aragonite-shelled fauna and also favoured outstanding preservation of the rich benthic micro-, meso- and macrobiota as well as the planktonic microbiota.

The Tertiary succession above the Cerithium Limestone Member at Stevns Klint is represented by the prominent bryozoan limestone mounds clearly outlined by dark flint bands (Fig. 13). The limestone comprises a mound complex of a type characterising much

of the Danish Danian where it is typical of the relatively deeper water setting during the early Tertiary (Thomsen 1995; Surlyk 1997).

The dark flint bands outlining the mounds were originally formed by the chemical growth of tiny silica crystals in the fill of animal burrows formed below the sea-floor. The burrows were excavated by crustaceans living about 30 cm below the seafloor and the flint bands thus show a precise image of the seafloor surface and the outline of the mounded structures (Box 3). The mounds had a relief of about 5–10 m on the sea-floor and they were typically 50–100 m in the short

BOX 3: FLINT



Photo: Jakob Laurup

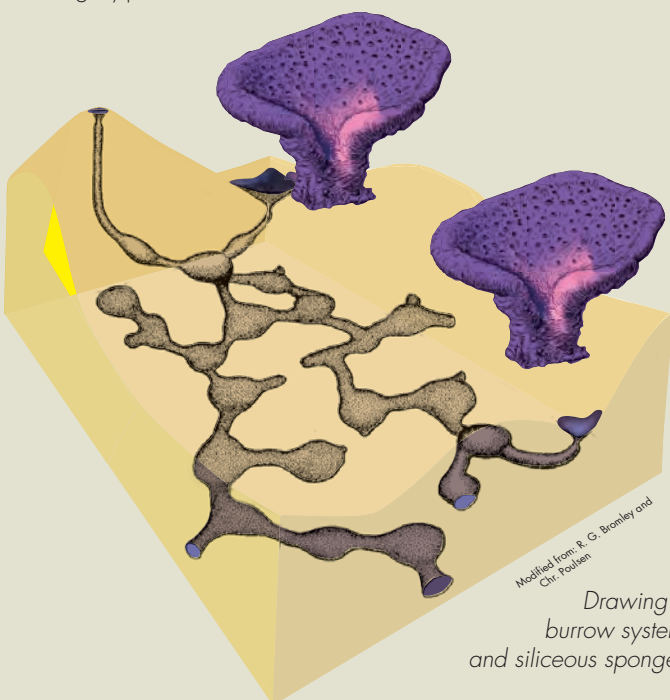
The flint bands in the chalk and limestone of Stevns Klint depict the outline of the ancient seafloor and mark episodes of reduced sedimentation or even periods of non-sedimentation (e.g. Clayton 1986; Madsen and Stemmerik 2010).

The nodular flint typical of Stevns Klint is formed by chemical processes in the fills of burrow systems formed by crustaceans that inhabited the seafloor. The crustaceans constructed their burrows in complex galleries about 30 cm below the seafloor and stabilised the burrow walls with mucus. When sedimentation on the seafloor was slow, the burrows were re-used by generations of crustaceans that stabilised the burrows and increased the concentration of organic material, resulting in marked textural and geochemical contrasts between the loose fill of the burrows and the more tightly-packed burrow walls.

The first step in flint formation started when continued sedimentation on the seafloor buried the burrowed chalk layer deeper below the seafloor where it reached the redox boundary. Just above the redox boundary, a narrow zone of reduction of sulphate and oxidation of sulfides resulted in lowered pH and dissolution of carbonate and in the flocculation of dissolved silica in the pore water forming the precursor of flint (Clayton 1986; Madsen and Stemmerik 2010). During periods of reduced sedimentation, the position of the redox boundary remained stable for a relatively long period of time, favouring this initial phase of flint formation.

The crystallisation of the flint precursors to microcrystalline quartz occurred at greater depths with increasing compaction and temperature.

Because the silica was dissolved before being reprecipitated, it is no longer possible to detect the origin, but it is generally assumed that the silica was derived from siliceous sponges and possibly also radiolarians and diatoms.



Drawing of burrow systems and siliceous sponges.



Photo: Anthony Martin

The present day Ghost Shrimp (*Callinectes major*) makes burrow systems similar to those found in the chalk and limestone.



axis and up to 300 m in the long axis. In plan view the mounds are elongated oval forms, and their long axes are oriented WNW–ESE (Bjerager and Surlyk 2007 a,b).

Faunal diversity in the bryozoan mounds is high, comprising mainly millimetre-sized suspension feeders (Bjerager and Surlyk 2007a,b). Bryozoans dominate in both species number and volume, and the delicate branching bryozoans are the main skeletal contributors typically comprising 20–45% of the rock. Other biotic elements include echinoids, serpulids, crinoids, asteroids, brachiopods, bivalves, sponges, benthic foraminifers and gastropods (present as casts in hard-grounds).

Detailed studies have shown that the bryozoans exerted a major influence on mound growth and the mounds are interpreted to be mainly biogenic structures formed when bryozoans preferentially grew in a southerly direction in the face of a nutrient-bearing current (Bjerager and Surlyk 2007b). The coastal cliff of Stevns Klint offers superb exposure of the bryozoan mounds, and along the cliff the mounds can be studied from different angles in minor bays. Additionally, exposure is visible on the modern seafloor in front of the cliff, in the 1.6 km long tunnel system that forms the Cold War fortress Stevnsfort, and in abandoned limestone quarries. The different types of exposure provide an excellent 3D dataset displaying the structures of the mound complex.

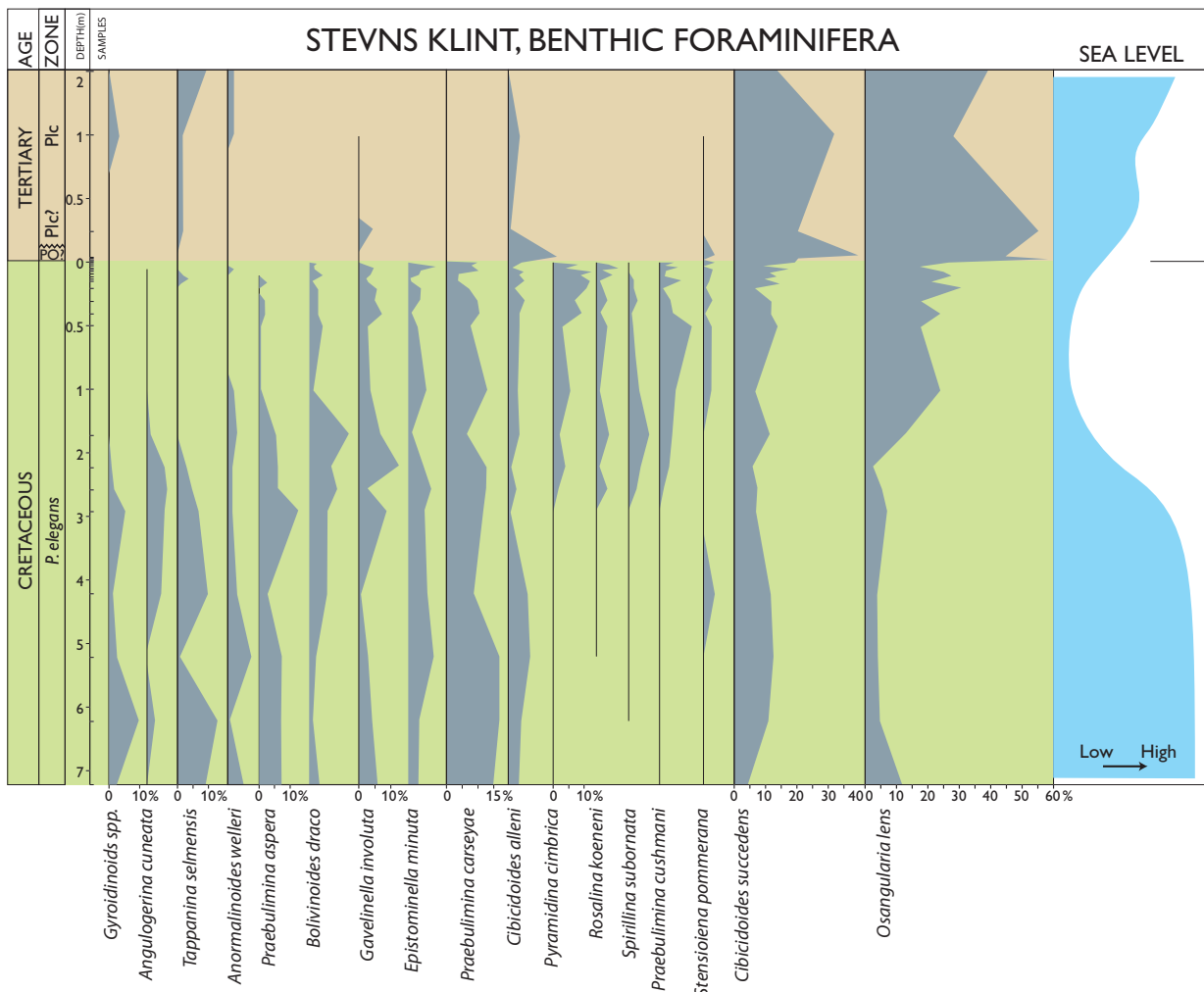


Figure 14. Biotic turnover at the Cretaceous–Tertiary boundary illustrated by the distribution of foraminifers (after Schmitz et al. 1992).

FOSSILS

SELECTION

OF MACROFAUNA FROM THE



Crustacean
Linuparis



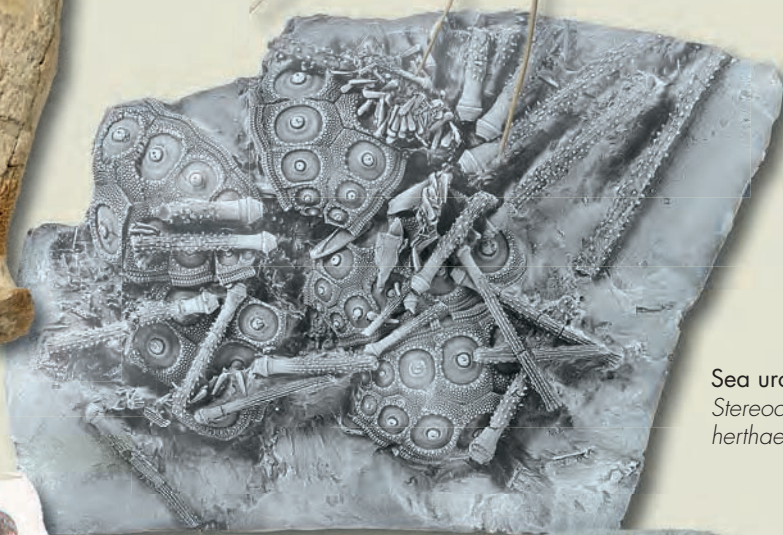
Coral
Parasimilia



Crustacean
Scalpellum
(*Arcoscapellum*)



Molluscs
Spondylus



Sea urchin
*Stereocidaris
herthae*



Shark teeth
*Cretalamna
appendiculata*



Sea urchin
*Tylocidaris
ballica*



Starfish
*Metopaster
poulsenii*

Sharpshoot: Jan Schulz, Adalstein

STEVNS KLINT

Sea urchin
Stereocidaris herthae

Eel fish
Anguilliformes
gen. et sp.
indet

Nautiloid
Eutrephoceras



Tube worm
Neovermilia



Bryozoan
Canalipora

SECTION



Teleost
Cyllindracanthus



Ammonite
Hoploscaphites



Brachiopod
Gemmarcula
humboltii



Brachiopod
Thecidea
recurvirostra



Sea sponge
Ventriculites

Photos: Steen Lammert-Jakobsen

All Photo: Steen Lammert-Jakobsen



NOMINATION OF STEVNS KLINT

The biota across the boundary

The nominated Stevns Klint site is among the best localities worldwide for studying the biotic turnover at the Cretaceous–Tertiary boundary. At Stevns Klint, the sediments both below and above the boundary are excellently suited for comparison as they reflect deposition in similar settings on a soft carbonate seafloor. The boundary is complex but well documented and offers one of the most expanded Cretaceous–Tertiary sections worldwide, displaying all known biozones, and it has excellent preservation of a high diversity micro-, meso-, and macrobiota with more than 830 species of macrobiota alone and in addition hundreds of species of nanno- and microfossils (Heinberg 1999, 2005, Appendix 3.1).

Among the more spectacular findings at Stevns Klint is the short-time survival into the Tertiary of ammonites – a group that was highly characteristic of Mesozoic seas and generally considered to have become extinct at the boundary. At Stevns Klint, several surviving species have been recorded in the Tertiary Cerithium Limestone (Surlyk and Nielsen 1999; Machalski and Heinberg 2005).

The similarity in environment and preservation history across the boundary makes it possible to compare the biota below and above and to eliminate the effects caused by changes in environment or in the history of preservation. The expanded section in the southern part of the cliff allows detailed sampling essential for recording the biotic changes and avoiding artificial exaggeration of the changes. Thus, the Stevns Klint site is among the best localities worldwide for studying the biotic turnover at the boundary.

Studies of the biotic turnover at the boundary show a dramatic fall in primary production with no fossils found in the clay immediately above the boundary defined by the iridium-anomaly at its base and with an associated dramatic loss of species. The extinction affects a range of successful invertebrate groups with foraminifers, gastropods, cheilostome bryozoans, brachiopods and bivalves suffering between 70 and 90%



Illustration: Carsten Egestal Thuesen

extinction on the species level as recorded in the Danish Cretaceous–Tertiary boundary sections (Hansen 2010; Heinberg 1999, 2005; Håkansson and Thomsen 1979; Surlyk and Johansen 1984) (Fig. 14). The large marine lizard, the mosasaur, suffered total extinction at the boundary. Two mosasaur species have been identified at Stevns Klint, and fossils found close to the boundary place them among some of the youngest recorded worldwide (Lindgren and Jagt 2005) (Fig. 15).

The biotic recovery after the mass extinction event is illustrated by the recovery pattern exhibited by bivalves. Immediately after the event, a few surviving species completely dominated the fauna with one sin-



Figure 15. The mosasaur – a large marine reptile of the Cretaceous sea.

gle species (*Corbulamella* sp.) showing extreme dominance of 60–90%. These few species that were the first to inhabit the seafloor after the impact are characterised as disaster species. Gradually up through the Cerithium Limestone, more species occur and the species diversity gradually increased until it reached a level similar to the layers below the boundary (Heinberg 2005). The number of species thereafter remained constant but the balance between individual species changed until a new and more stable community was established.

The well-preserved biota at Stevns Klint illustrates the abrupt fall in productivity at the boundary, the total extinction of several groups and the dramatic extinction on a species level of a range of invertebrate groups. Subsequently, productivity increased and life slowly recovered with the presence of few disaster species followed by a slow build-up of a complex ecosystem.

Mosasaur tooth
(*Plioplatecarpus* sp.)
from Stevns Klint.
2.5 cm.

Photo: Sten Lennart Jakobsen

The Importance of Stevns Klint in the History of Science

History of Earth science: Stevns Klint

The nominated Stevns Klint has a strong historical significance for the study of the Cretaceous–Tertiary boundary. The published information concerning the nominated locality spans more than 250 years and the observations from this long period reflect the steps in the development of the geological science, and illustrates the discussion of uniformitarianism versus catastrophism. Since the presentation of the asteroid impact theory in 1980 by Alvarez *et al.* (1980) the nominated Stevns Klint has had a central role in the study of mass extinctions, and the present day scientific interest in Stevns Klint is very high.

Early scientific description

The early studies of Stevns Klint were driven by the general optimistic belief in the 17th and 18th century that the natural resources could be used to support development of the economy (Garboe 1959). The mercantile interest was supported by the Danish kings, and led to many initiatives of geological mapping and description.

In the 18th century the Danish King Frederik the 5th praised the earth scientist and skilled artist Abildgaard (1718–1791) and asked him to study Stevns Klint in detail. Abildgaard produced a thorough description of the entire cliff from north to south focusing on the thickness of the soft chalk, the overlying hard limestone, and on the flint layers. Abildgaard included de-

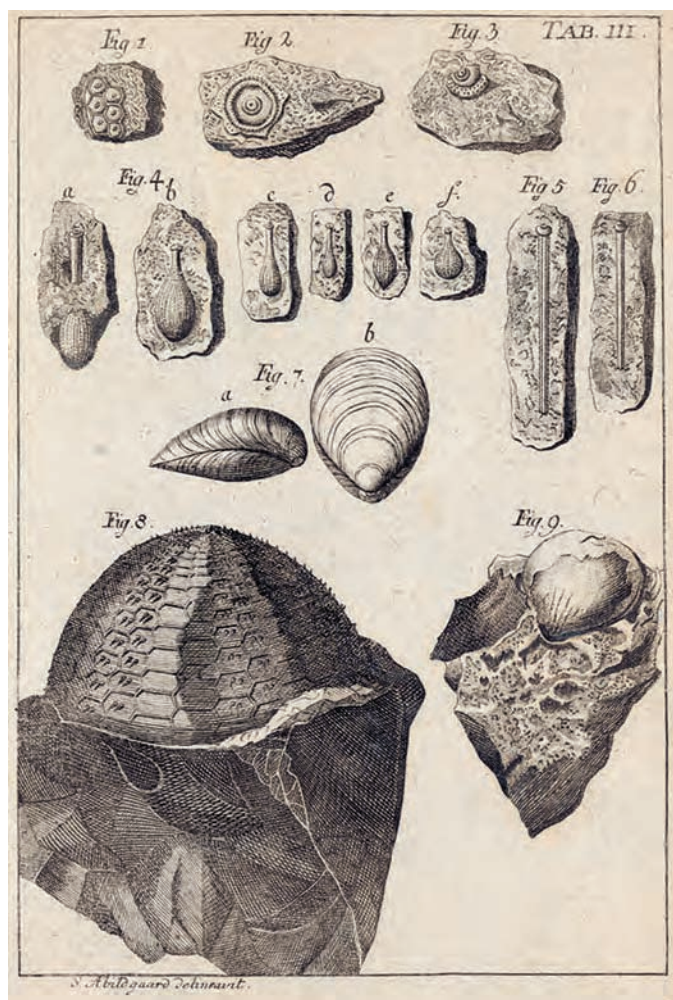
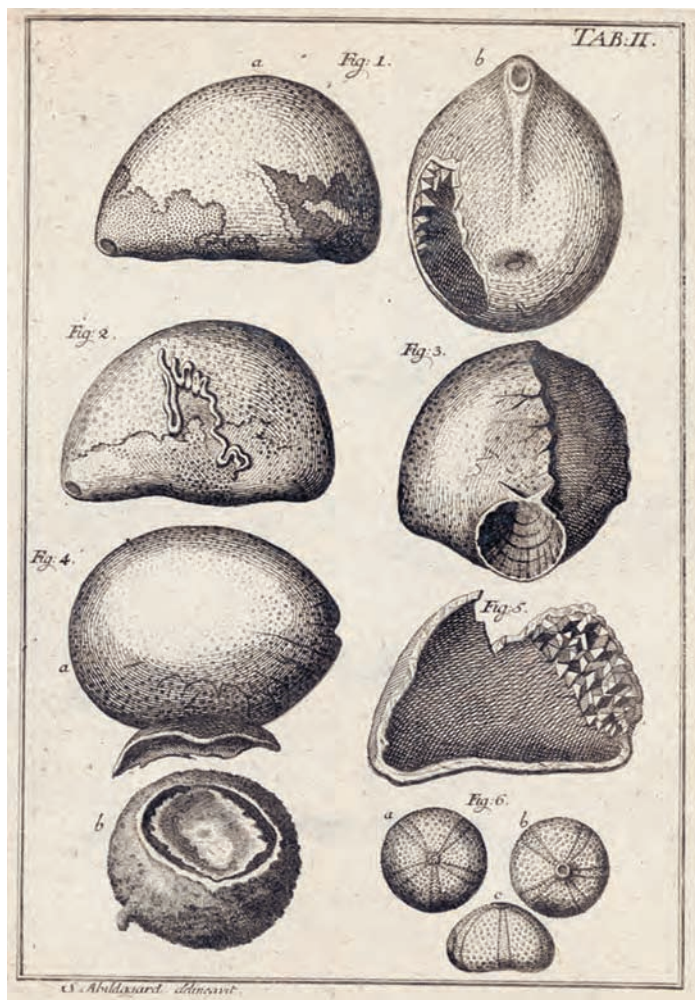


Figure 16. Fossils from Stevns Klint drawn by Abildgaard (1759).



Figure 17. Detailed drawings of Stevns Klint by Abildgaard (1759), representing the oldest known illustration of the cliff. Note that the Højerup church is still intact on the edge of the cliff.

tailed drawings of fossils found in the cliff, and presented the oldest known profile (Fig. 16,17). Although the paper is mainly of descriptive character Abildgaard speculated on the enigmatic occurrence of marine fossils high above the sea, and on the formation of flint. In accordance with scientific thinking of his time Abildgaard suggested that this was caused by the catastrophic Flood of Noah recorded in the Bible or by uplift due to violent fires and movements within the Earth (Abildgaard 1759).

Modern geology

Throughout the 19th century many fundamental aspects of modern geology were established. The ‘catastrophist’ explanations of the origin of geological layering, including the Flood of Noah described in the Bible were challenged by the idea of ‘uniformitarianism’ that the Earth was shaped by slow-moving forces still in operation today as popularized by Charles Lyell (1833). For the geological science also the general framework of stratigraphic correlation was in focus. The nominated Stevns Klint attained the interest of

major figures in geology mainly concerned with correlation of the strata.

The Swiss geologist Pierre Jean Édouard Desor visited Stevns Klint and Faxe in 1846. Based on correlation to the Parish Basin Desor defined a new period and named it ‘Terrain Danien’ after Denmark (Desor 1847), with the nominated Stevns Klint the type locality for the Danian Stage (Box 4). At that time the Danian was considered the uppermost stage in the Cretaceous System.

Prior to the visit of Desor the leading Danish geologist professor Johan G. Forchhammer had described the layering of Stevns Klint, including the boundary clay (Forchhammer 1825). He correlated the clay with the French Paleocene / Eocene deposits *Argile plastique* and the equally Danian Faxoe Limestone with the Eocene French *Calcaire grossier* from the Paris basin. Both these deposits are considerably younger than the Danian.

BOX 4: THE DANIAN

The lower period of the Tertiary Era is named the Danian after Denmark, where strata of this age were first recognised by Desor (1847) after his visit to Stevns Klint and the nearby Faxø quarry.



Édouard Desor.

Forchhammer later presented his idea in the *Edinburgh Journal of Science* (Forchhammer 1828) and awoke the interest of the famous British geologist Charles Lyell who visited Denmark in late May 1835.

Lyell drew several geological sketches of Stevns Klint which were later published in *Transactions of the Geological Society of London* (Lyell 1837) (Fig. 18). The sketches reveal that Lyell accepted the misinterpretation of Forchhammer that the Cerithium Limestone could be correlated to the somewhat younger Danian limestone at Faxø, an understanding that was not challenged until Johnstrup in 1876 correctly concluded that these were two independent units.

In 1835 Forchhammer admitted his miscorrelation of the boundary strata with the *Argile plastique* and the *Calcaire grossier*, undoubtedly under the influence of Lyell.

Alfred Rosenkrantz, who later became professor in geology in Copenhagen, clarified the complex structure of the boundary layers (Rosenkrantz 1924, 1939, 1966). Earlier workers had collected indiscriminantly in the topmost hardened Cretaceous chalk and the intervening rather similar lowermost Danian Cerithium Limestone, thereby mixing the faunal assemblages from the two units. This resulted in the wrong assumption of a gradual faunal transition from the Cretaceous into the Danian (Ravn 1902a, 1902b, 1903, 1904; Nielsen 1912, 1917). Rosenkrantz demonstrated that what hitherto been called *Cerithium Limestone* comprised a mixture of hardened topmost Maastrichtian white chalk stratigraphically overlain by the boundary clay and the equally hardened lowermost Danian limestone – the Cerithium Limestone Member of modern usage – overlying the clay. He showed that the two limestones contain markedly different faunas and that the fauna of the Cerithium Limestone Member has a strong affinity to the Danian.

The Danian Stage was originally defined as the uppermost stage in the Cretaceous System for the obvious reason that the succession in the type area Denmark consists of limestones which also characterizes the Upper Cretaceous throughout Europe – mainly in the form of chalk. In the 1950s and 1960s it was realised that a major biotic overturn took place at the boundary among planktonic foraminifera and coccoliths. The overturn was later recognized as representing one of the ‘big five’ mass extinctions. It was thus seen as a logical consequence to refer the Danian to the Tertiary and in 1989 the International Subcommission on Palaeogene Stratigraphy, was subdivided into seven stages starting with the Danian.

Describing the fossils

In the following decades the research on the nominated Stevns Klint mainly focused on taxonomic stud-

1759: Søren Abildgaard provides a thorough description of Stevns Klint, including the first known illustration of the cliff profile and of fossils.

1764: Erik Pontoppidan includes Stevns Klint into his "*Great Atlas of Denmark*", including illustrations.

1776: Niels H. Weinwich includes comments on fossils and the cliff in his book on "*Stevns Herred*"

1820: Edouard V. Bedemar published a short paper on the geology of Stevns Klint.

1825: Johan G. Forchhammer describes the Cretaceous chalk and the Tertiary clay and Limestone.

The work includes detailed description of the fossil content and lithology of the succession exposed in the cliff. In this paper Forchhammer concludes that the boundary clay and the overlying limestone belong to the Tertiary based on a miscorrelation with the younger French *Argile plastique* and the Faxøe Limestone with the French *Calcaire grossier*.



Johan G. Forchhammer
(1794–1865).

1828: J. G. Forchhammer publishes a paper in *Edinburgh Journal of Science* with the conclusions he made in his 1825 paper. This paper caught the attention of Sir Charles Lyell on the Cretaceous deposits of Denmark and inspired him to visit Forchhammer and inspect the localities himself.

1835: J. G. Forchhammer publishes a paper on the geology of Denmark in which he changes the age assignment of the clay and the overlying limestone from the Tertiary to the Cretaceous.



Charles Lyell
(1797–1875).

1837: Charles Lyell publishes "*On the Cretaceous and Tertiary Strata of the Danish Islands of Seeland and Møen*" in which he describes the lithology of the cliff and the fossil content and includes illustrations of the stratigraphy. Lyell was convinced that the clay and the Cerithium Limestone belonged to the Cretaceous.

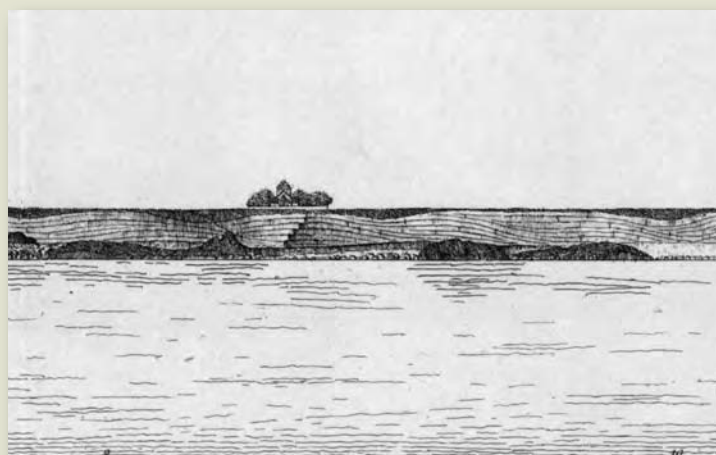
1847: Jean Pierre Édouard Desor erects and names a new stage following his visit to Stevns Klint and Faxø, and names it Terrain Danien (Danian) after Denmark.



Johannes Frederik Johnstrup
(1818–1894).

1853: Christopher Puggaard produces the first detailed profile of the entire length of the cliff.

1876: Johannes F. Johnstrup coins the name Fish Clay (Fiskelejer) to the boundary clay after its contents of fish debris.



Short fragment of the complete and detailed mapping of Stevns Klint produced by Puggard (1833).

1924: Alfred Rosenkrantz unravels the detailed stratigraphy of the boundary succession Stevns Klint and illustrates how mixing of collections of fossils from the uppermost Cretaceous chalk and the lowermost Tertiary Cerithium Limestone resulted in the idea of a gradual faunal transition across the boundary.

1955–1980: More than 30 papers on taxonomy and palaeoecology of Stevns Klint.

1973: Christensen *et al.* present the first detailed description of the boundary clay.

1980: Alvarez *et al.* publish the seminal paper on the asteroid impact hypothesis based on the iridium anomaly in the boundary clay.

1980-2010: More than 90 papers published on the geochemistry, palaeontology and sedimentology of the Stevns Klint succession. A large part of these studies are by non-Danish workers.

2004: Lykke-Andersen and Surlyk: Reflection seismic profiles recorded along the length of the cliff show that the Cretaceous chalk was sculpted into large ridges and valleys by strong bottom currents and demonstrates that the different height of the boundary along the length of the cliff reflects an original seafloor topography and not folding as believed for more than 70 years.

2004, 2005: Hart *et al.* present a very high-resolution foraminifer zonation and stable isotope profile across the boundary from an expanded section in the northernmost part of the cliff.

2005: Rasmussen *et al.* study the combined development of foraminifers and bivalves across the boundary.

2006: Stemmerik *et al.* present the first results of two scientific boreholes were drilled down to depths of 340 m and 456 m at the southern and northern parts of the cliff, respectively.

2006: Surlyk *et al.* introduce formal stratigraphic names for the Stevns Klint succession and present a complete profile of the cliffs based on stereo-photogrammetry.

NOMINATION OF STEVNS KLINT

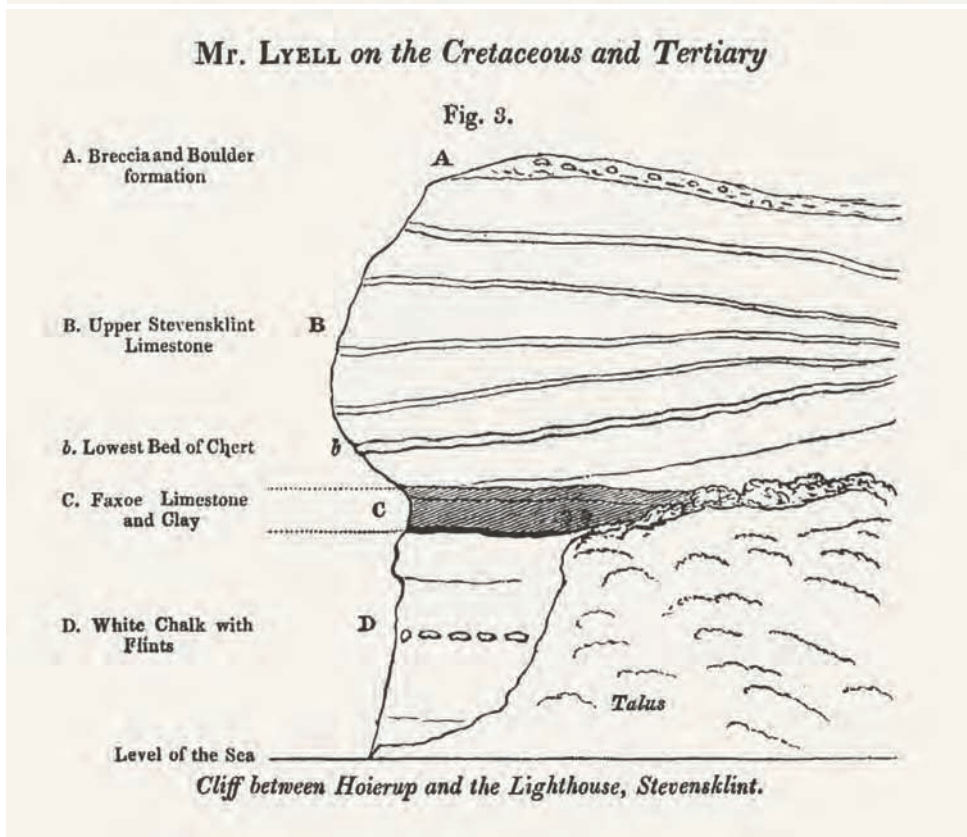
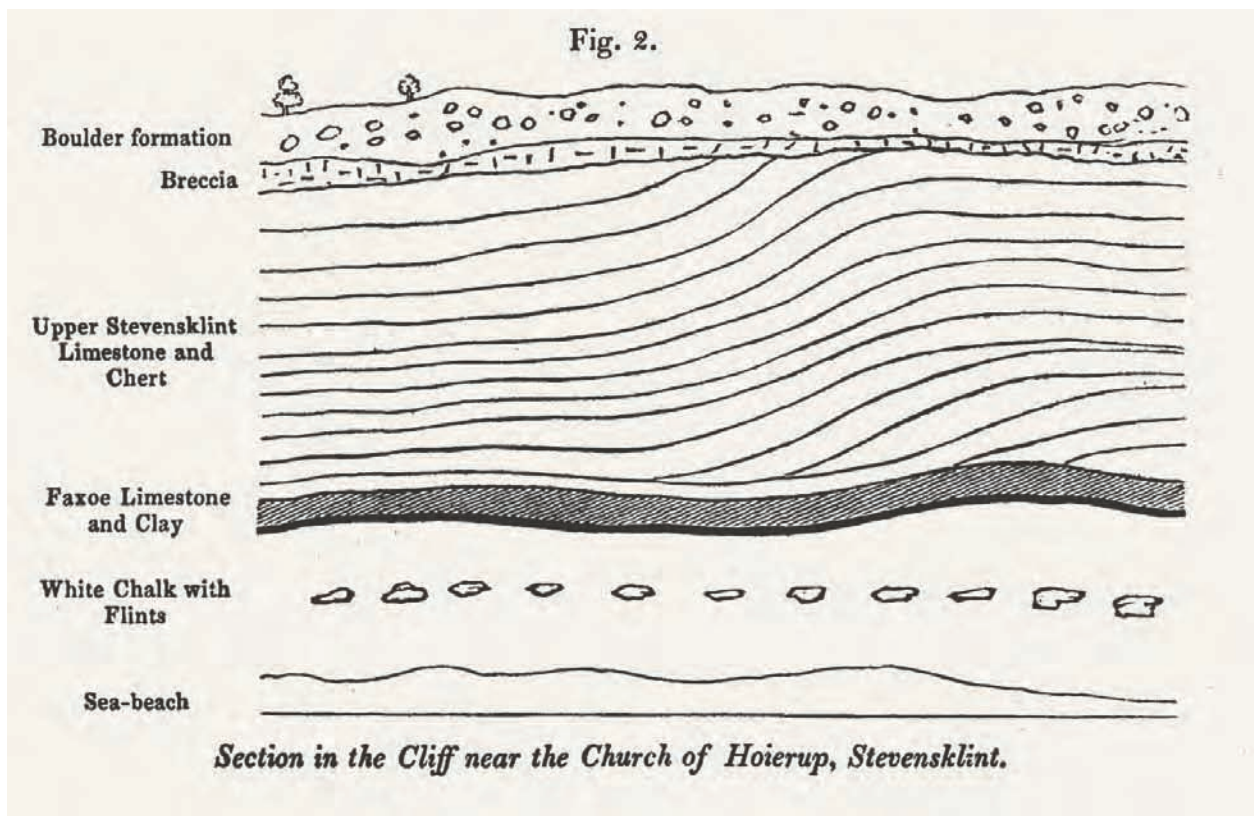


Figure 18. Sketches by Charles Lyell of the nominated Stevns Klint (Lyell 1837).



Photo: GEUS

ies illustrated by the works of Rosenkrantz (1939), Troelsen (1955), Wind (1954, 1959), Hofker (1960) and Perch-Nielsen (1969).

In the 1960s and 1970s the studies of Stevns Klint increased dramatically mainly due to the efforts of a group of Danish geologists from the University of Copenhagen who focused on different aspects of the Cretaceous and Tertiary deposits in Denmark and partly because the nominated Cretaceous–Tertiary boundary section Stevns Klint had gained international attention among professional geologists as the 21st International Geological Congress (IGC) was held in Copenhagen (1960). More than 2300 geologists attended the congress that included a thematic session on the Cretaceous–Tertiary boundary, and a field excursion to the nominated Stevns Klint led by Professor A. Rosenkrantz (Sørensen 2007).

Field trip to Stevns Klint 1904.

From this period papers include studies on belemnites (Birkelund 1957; Christensen 1979), bivalves (Dhondt 1971, 1972; Heinberg 1976, 1979a, 1979b; Perch-Nielsen 1969), brachiopods (Surlyk 1970, 1972, 1973, 1979), bryozoans (Berthelsen 1962; Cheetham 1971; Brood 1972; Jürgensen 1971), corals (Floris 1979), crinoids, asteroids and ophiuroids (Rasmussen 1979), dinoflagellates (Hansen 1977, 1979), echinoids (Wind 1954, 1959; Gravesen 1979), foraminifera (Berggren 1962; Hofker 1960, 1962), nannoplankton (Bramlette and Martini 1964), ostracodes (Jørgensen 1976, 1978), and trace fossils (Bromley 1967, 1968; Rasmussen 1971). Additionally the first detailed description of the boundary was presented by Christensen *et al.* (1973).



Photo: Jan Smit

Figure 19. Field trip to Stevns Klint at the Cretaceous–Tertiary Symposium in Copenhagen, 1979.

The impact theory and beyond (1980–recent)

In 1979 the University of Copenhagen hosted an international symposium on the Cretaceous–Tertiary boundary event, including a field-trip to the nominated Stevns Klint (Fig. 19). At this symposium an early version of the asteroid impact hypothesis was presented by Walter Alvarez followed by intense discussions at the symposium as described by Walter Alvarez in his book ‘T. rex and the Crater of Doom’ (1997) (Box 1).

The famous asteroid impact hypothesis as an explanation for the mass extinction at the boundary was published in 1980 (Alvarez *et al.* 1980) leading to an intense debate (Box 1). The nominated Stevns Klint was one of the original discovery localities of the iridium anomaly found in the boundary clay and Stevns Klint is still among the localities with the highest iridium content detected.

The impact hypothesis triggered a new wave of studies focused on the nominated Stevns Klint site especially

on stable isotope trends across the boundary and other types of geochemical analyses. Following the 1980-paper more than 60 papers are published with chemical or mineralogical analysis of material from Stevns Klint and more than 30 papers on the palaeontology across the boundary. For references see section 7.e. Most recently several high resolution studies have appeared on the foraminifer zonation and the stable isotopes across the boundary (Hart *et al.*, 2004, 2005; Rasmussen *et al.*, 2005). Sepulveda *et al.* (2009) studied the molecular remains of microorganisms in the Fish Clay and found that the primary production in the sea covering the Stevns Klint area recovered extremely rapidly after the impact. The high, and still increasing number of papers published in recent years clearly indicates that the nominated Stevns Klint site is a very important locality for the study of the mass extinction, climate change and depositional processes across the Cretaceous–Tertiary boundary.



Photo: Jakob Laurrup

Figure 20. Glacial deposits (brown) at the top of the cliff.

Post-Danian Uplift and Erosion

Following deposition, the chalk and limestone was covered by approximately 500 m of Tertiary to Pleistocene sediments (sand, clay and glacial diamicts). Neogene uplift brought the chalk and limestone deposits up to the present-day level and erosion has removed all 500 m of siliciclastics and the uppermost part of the Danian limestone (Nielsen *et al.* 2011).

The last phases of erosion took place during multiple Pleistocene glaciations when the Stevns Klint area was situated along the fringes of consecutive Scandinavian ice sheets. Consequently, the area was covered by a number of individual ice advances streaming from the main ice sheet (e.g. Houmark-Nielsen and Kjær 2003). Except for small-scale fracturing and jointing of the chalk and limestone the ice streams did not cause any disturbances and left the boundary section intact.

The erosional surface at the top of the Danian limestone formed by the glacial erosion is overlain by thin glacial diamict (Fig. 20). The diamict was deposited by the last three ice streams that covered the area (Fig. 21).

Cliff Formation

After withdrawal of the ice sheet, *c.* 16,000 years BP, the Baltic Sea area experienced a complex sea-level/lake-level history caused by the interplay between eustatic rise and isostatic uplift (e.g. Björck, 1995). However, until *c.* 7,000 years BP, the Stevns Klint area was well above water level and the area was covered by dense vegetation.

A rapid sea-level rise started *c.* 8,000 BP and brought sealevel in the Stevns Klint area close to the present level, culminating *c.* 6,000 BP in a sealevel 2 m above the present. The rising sea initiated the formation of the first coastal cliff and hereafter wave erosion has caused slow but steady retreat of the cliff.

NOMINATION OF STEVNS KLINT

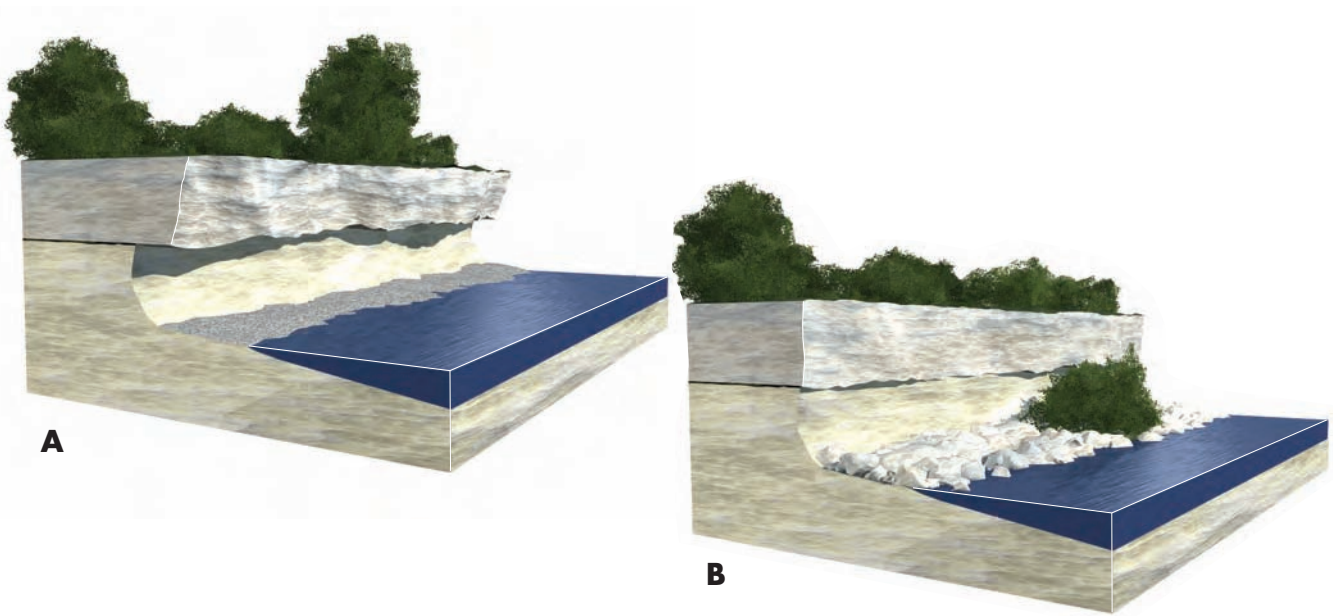


Figure 22. Block diagrams illustrating the process of coastal erosion. A) Coastal waves erode the soft Cretaceous chalk in the lower part of the cliff forming a pronounced overhang of overlying harder Tertiary limestone. B) The overhang collapses. The blocks on the beach are slowly eroded by storm waves. Modified from Pedersen 2011.

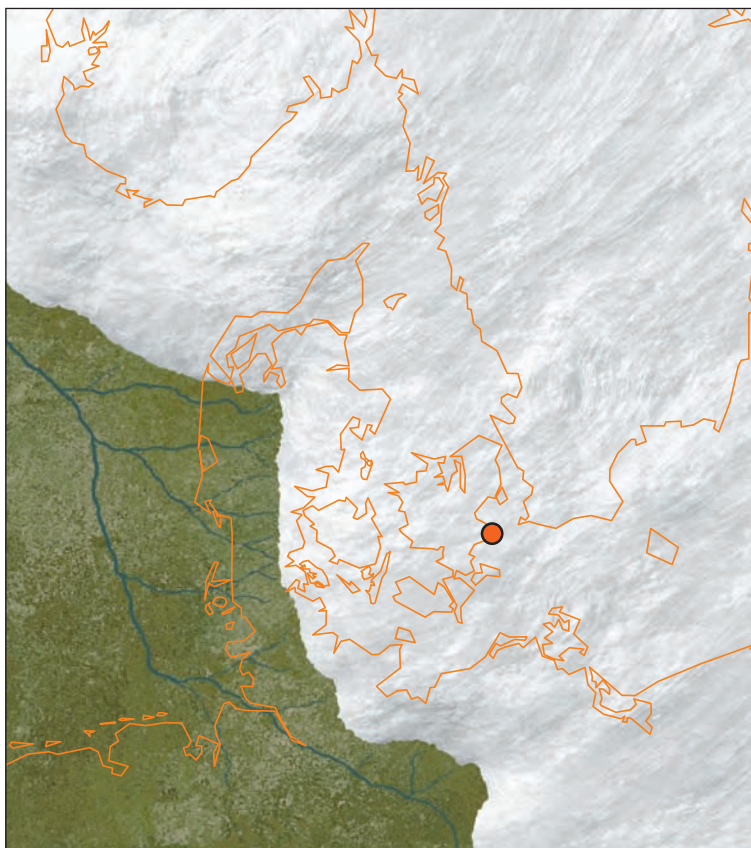


Figure 21. Ice sheet covering the nominated area c. 23,000–20,000 years BP (based on Houmark-Nielsen 2011).

Illustrations: Stefan Saltherg

Storm waves erode the soft chalk in the lower part of the cliff causing an overhang to form and eventually break off to form a rock fall (Fig. 22). Based on histori-

cal and present-day erosion, the average rate of erosion is estimated to be c. 15 cm/year (Appendix 5).

Wildlife Interests of the Nominated Site

The steep white cliff of chalk and limestone distinguishes the nominated Stevns Klint area from the surrounding landscape and forms a major influence on the wildlife on a local and regional scale.

Migrating Birds

The steep white cliff of Stevns Klint, bordering the Stevns peninsula provides a unique combination of geography and topography that makes it a significant site for migrating birds on a regional scale (Heat and Evans 2000). A total of 260 species have been observed along the cliff an estimated 200 of which are migrating birds (Appendix 3.3). Based on the annual passing of 20,000 migrating birds of prey, Stevns Klint has been registered as an IBA (important bird area) by BirdLife International (Fig. 23).

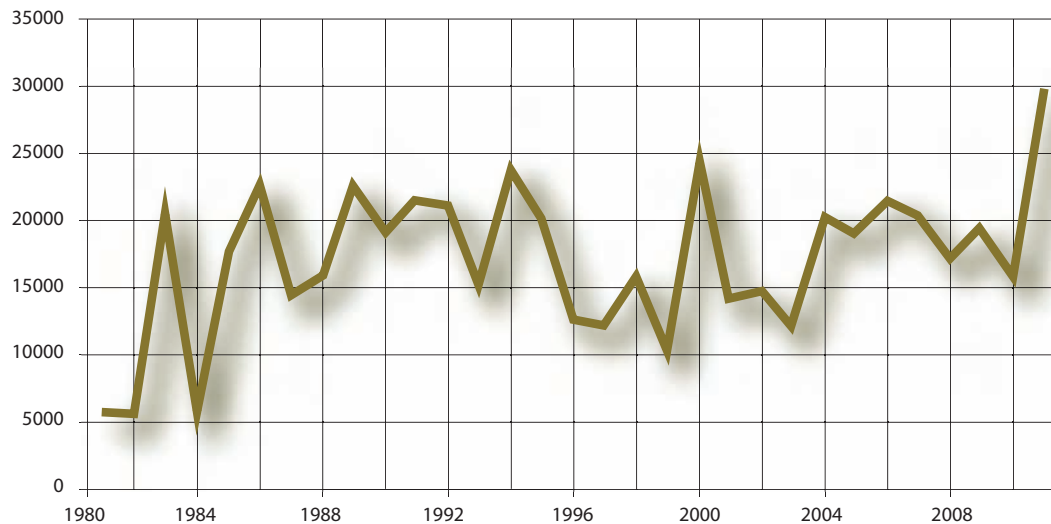


Figure 23. Passings of migrating birds of prey at Stevns Klint in the autumn of 1980–2010 (Andersen, 1993 and unpubl. data). Large annual variations are due to changes in the prevailing winds and, to some extent, changes in observer coverage.

Stevns Klint lies on an important bird migration route, connecting the large breeding areas of northern Scandinavia and the winter quarters in the Mediterranean to tropical Africa. One of the large sea crossings on this route is the Øresund strait between Denmark and Sweden. The Stevns peninsula stretches out into the Øresund strait and the 25 km separating Stevns Klint from the other side of the strait provide the shortest sea crossing of this part of the route. Thus, geographically Stevns Klint is an important site for migrating birds on a regional scale.

The most spectacular sights occur during autumn days of clear weather when hundreds or even thousands of birds approach the cliff from the sea, having chosen the shortest crossing distance and using the tall white cliffs of Stevns Klint as a marker (Fig. 24). Bird watchers gather to enjoy the numerous migrating birds of prey that approach the cliff after the tiring crossing and the impressive view when the birds reach the updraft produced by the steep cliff and start circling to regain height.

Honey buzzards, buzzards and sparrowhawks appear at Stevns Klint in large numbers together with fair numbers of red kite, marsh harrier, hen harrier, rough-legged buzzard, osprey, kestrel and merlin. Species that turn up each year, but only in small numbers, are black kites, white-tailed eagles, pallid harriers, Montagu's harriers, goshawks, hobbys and peregrines, and very rare guests are short-toed eagles, long-legged buzzards, spotted eagles, lesser spotted eagles, steppe eagles, imperial eagles, golden eagles, booted eagles, red-footed falcons and gyrfalcons (Klein 2011).

Flora and Fauna of the Cliff and the adjacent Grassland

Stevns Klint stands out from the surrounding flat moraine landscape with its steep cliff face of hard limestone. The east-facing, steep, windy cliff, the abandoned limestone quarries, together with the areas of calcareous dry grassland along the top of the cliff, houses habitats rare for the region and makes the nominated Stevns Klint site important for the regional diversity of flora and fauna.

NOMINATION OF STEVNS KLINT

Figure 24. Birds of prey over Stevns Klint.



Photo: T.W. Johansen



Photo: P. Nergaard

Birdwatchers looking for migrating raptors.

Flora: The vegetation of the cliff face itself is generally sparse due to the constant erosion and the high degree of sun exposure so that only a few species that are adapted to these harsh environments grow here. Minor areas of higher stability form unique microhabitats with a range of species characteristic of a calcareous grassland flora. In the abandoned quarries, the lack

of a mull layer provides a rare nutrient poor environment, leading to a sparse open vegetation.

During the last 30 years, a total of 43 ha of land along the cliff has been transformed from agricultural fields into grassland and the flora from the cliff now appears in increasing numbers in these areas. A total of 243

2. DESCRIPTION



Photo: Jakob Laurup

Vegetation on the cliff.

NOMINATION OF STEVNS KLINT

GRASSLAND FLORA



Saxifrage
Saxifraga granulata



Brown
Knapweed
Centaurea jacea



Bladder Campion
Silene vulgaris



Pigeon's Scabious
Scabiosa columbaria



Yarrow
Achillea millefolium

All Photos: Kiriine Oberggaard

2. DESCRIPTION



Cowslip
Primula veris

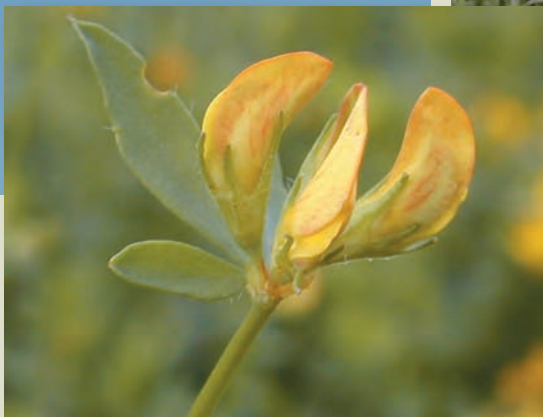


Quaking Grass
Briza media



Common Restharrow
Ononis repens

All Photos: Kristine Oberggaard



Bird's-foot Trefoil
Lotus corniculatus

Tansy
Tanacetum vulgare



Greater Knapweed
Centaurea scabiosa

CHARACTERISTIC DRY GRASSLAND FLORA

Irish Fleabane	<i>Inula salicina</i> L.
Carlina Thistle	<i>Carlina vulgaris</i> L. ssp. <i>stricta</i> (Rouy) Domin
Common Valerian	<i>Valeriana officinalis</i> L. ssp. <i>officinalis</i>
Hawkweed Oxtongue	<i>Picris hieracioides</i> L.
Rough Hawkbit	<i>Leontodon hispidus</i> L.
Knapweed Broomrape	<i>Orobanche eliator</i> Sutton
Upright Brome	<i>Bromus erectus</i> Hudson
Quaking-grass	<i>Briza media</i> L.
No Common English Name	<i>Hieracium cymosum</i> L.
Fairy Flax	<i>Linum catharticum</i> L.
Hairy Rock-cress	<i>Arabis hirsuta</i> (L.) Scop.
Peach-leaved Bellflower	<i>Campanula persicifolia</i> L.
Greater Knapweed	<i>Centaurea scabiosa</i> L.
Cowslip	<i>Primula veris</i> L.
Nottingham Catchfly	<i>Silene nutans</i> L.
Wild Marjoram	<i>Origanum vulgare</i> L.
Dropwort	<i>Filipendula vulgaris</i> Moench
Common Milkwort	<i>Polygala vulgaris</i> L.
Moonwort	<i>Botrychium lunaria</i> (L.) Swartz
Tall Rock-cress	<i>Cardaminopsis arenosa</i> (L.) Hayek
Small Scabious	<i>Scabiosa columbaria</i> L.
Black Medick	<i>Medicago lupulina</i> L.
Common Rock-rose	<i>Helianthemum nummularium</i> ssp. <i>nummularium</i> (L.) Miller
Glaucous Sedge	<i>Carex flacca</i> Schreber
Spring Sedge	<i>Carex caryophyllea</i> Latourr.
Dwarf Thistle	<i>Cirsium acaule</i> (L.) Scop.
Large Thyme	<i>Thymus pulegioides</i> L.
Fine-leaved Vetch	<i>Vicia tenuifolia</i> Roth

Table 1. Characteristic species at Stevns Klint. Knapweed Broomrape (*Orobanche eliator* Sutton) is listed Near Threatened on the Danish Red List.

species are recorded and of these, 97 species are characteristic of calcareous grassland vegetation (Table 1, Appendix 3.4).

Mammals: Mammals are represented by a range of species typical of the region, including the most common species fox, hare and roe deer. Most remarkable is the occurrence of seven species of bats found hunting in the area or roosting in various buildings including the church and Cold War installations (Baagøe and

Jensen 2007). At least two species of bats, Daubenton's Bat, *Myotis daubentoni*, and Natterer's Bat, *Myotis nattereri* hibernate in an abandoned tunnel associated with the Cold War fortress Stevnsfort (Fig. 25).

All bats are included in the EU Habitats Directive Annex IV and *Myotis nattereri* is listed as vulnerable on the Danish Red List 2010.



Photo: H. Boegge

Figure 25. Dauberton's Bat at Stevns Klint.

Birds: The cliff, thickets and grasslands provide ideal habitats for many birds, including threatened or rare species. The Peregrine Falcon (*Falco peregrinus*) disappeared as a nesting bird from Denmark in 1950. However, the peregrine is now back and since 2007 nesting on Stevns Klint (Fig. 26). The Peregrine Falcon is registered as vulnerable on The Danish Red List of Threatened Species together with the Common Merganser (*Mergus merganser*), which nests in small caves along the cliff close to the sea surface, and the Common Rosefinch (*Carpodacus erythrinus*), which is found nesting in the thickets along the top of the cliff (Wind and Pihl, 2004). The steep cliff is inhabited by one of the largest populations of Common House Martin (*Delichon urbicum*) in Europe. The Common House Martins build their mud nests directly on the cliff face.

Insects and spiders: The microclimates found on the warm south- and east-facing cliff and in the abandoned quarries and grasslands make Stevns Klint an attractive area for a vast range of insects. A number of insects

Photo: T. W. Johansen



Figure 26. Peregrine Falcon nesting at Stevns Klint.

NOMINATION OF STEVNS KLINT



Figure 27. Stevns Klint houses populations of insects and spiders otherwise rare in Denmark exemplified by the European Cave Spider (*Meta menardi*) (left) and Red-veined Darter (*Sympetrum fonscolombi*) (right).

Photo: T.W. Johansen

Photo: N. Sheeriff

rare in Denmark are found on the cliff or in the abandoned quarries. This includes species where the Stevns Klint area is the only registered occurrence such as the rove beetle species *Tomoglossa luteicornis*, and the Strawberry Root Weevil (*Otiorhynchus rugifrons*). The tunnels of the Cold War fortress house the European Cave Spider, *Meta menardi*, rare for the region (Fig. 27).

The high SE-oriented cliff projecting into the Øresund strait makes Stevns Klint the first landfall for warmer climate insect species from Central or Eastern Europe reaching the region with southeasterly winds. These species are generally found as single individuals or in very limited numbers but may potentially settle to form permanent populations.

The flowering dry grasslands offer particularly good conditions for butterflies, and 22 species of Danish butterflies are common together with rarer butterflies

and rare moths including the Morris' Wainscot (*Chorotodes morrisii morrisii*) and Tawny Pinion (*Lithophane semibrunnea*).

Reptiles: The sunny areas of low vegetation of the cliff and grassland make Stevns Klint an important habitat for reptiles, the populations of which are generally in decline in Denmark, including the common European Viper (*Vipera berus*) and the Sand Lizard (*Lacerta agilis*) (Fog *et al.* 2001). The Sand Lizard is included in the EU Habitats Directive Annex IV and protected by national legislation (Fig. 28).

Amphibians: Ponds in the abandoned quarry of Holtug Kridtbrud host a large population of Smooth Newt (*Triturus vulgaris*) and the rarer Great Crested Newt (*Triturus cristatus*), which are protected by the EU Habitats Directive Annex II and IV. Based on the calcareous ponds and the occurrence of Great Crested Newts, the abandoned quarry of Holtug Kridtbrud is



Figure 28. Sand Lizard (*Lacerta agilis*).

Photo: T. W. Johnsen

included in the European Natura 2000 network of protected areas.

The Marine Ecosystem

The marine ecosystem of the sea around Stevns Klint is closely linked to the chalk and limestone that extend seawards from the cliff and form the seafloor. The white and hard seafloor with scattered large boulders forms a contrast to the typical soft sandy and muddy seafloor that is characteristic of the region and hosts a stone reef along the length of the cliff, from the coastline and down to 15 m water depth (Fig. 29). The area is included in the European Natura 2000 network of protected areas.

Danish stone reefs comprise ecosystems with a large variation in production and species diversity, reflecting not only the substrate, energy level and water depth, but also the variation in salinity that changes gradually from fully marine conditions in the open part of Skagerrak to brackish conditions in the Baltic Sea area (Dahl *et al.* 2003). The stone reef at Stevns Klint is situated in the less saline part of the transitional zone southeast of the Danish straits.

The biodiversity of the scattered reef areas in Danish waters is sustained to a large degree by passive transport of larvae and spores by water masses. Due to its large size, great depth distribution and lack of other nearby reef areas, the reef along Stevns Klint acts as an important stepping stone for species and most likely serves as a link for biological connectivity between reef areas in Kattegat and the Baltic Sea area.

Species of macroalgae are mainly found on boulders but are also present on the chalky seabed (S. Lundsteen pers. com.). The seaweed is totally dominated by red algal species that completely cover all boulders to a water depth of 15 m. *Furcellaria lumbricalis*, *Polysiphonia fucoides* and *Polysiphonia fibrilosa* cover most of the suitable hard seabed but other leaf-forming red algal species like *Coccotylus truncatus* and *Deleseria sanguinea* are also common and the large brown algae *Saccharina latissima* is also present. The blue mussel, *Mytilus edulis* is extremely common on the reef and is often found entangled in the algal vegetation. Both the blue mussel and several algal species have special dwarf forms in this relatively low salinity water.



Photo: Karsten Dahl

Figure 29. The hard seafloor offshore Stevns Klint serves as substrate for a protected stone reef.

The white seafloor with the characteristic reef species is intersected by fractures forming one-metre deep elongated fissures placing the seafloor along Stevns Klint among the most scenic of the region and making it a popular location for scuba diving.

The Extent and Method of Exploitation

The history of exploitation is described in section 2.b. Exploitation is not in operation in the nominated area but traces still exist of past exploitation and exploitation occur in a neighbouring area.

Two open quarries each covering around 5 ha were abandoned in the 1970s and form part of the nominated area (Appendix 1). The quarries were established during the last century behind the cliff with open access to the sea to allow transport of material by boat. Traces of a production of building blocks directly

off the cliff face from a period between about 1850 to about 1950 are still visible along the cliff (Section 2b). Today, the traces are slowly disappearing because of coastal erosion.

The open quarry Sigerslev neighbouring the nominated area is still operating. This quarry is not part of the nominated site and is strictly controlled by Danish legislation, which ensures that production does not affect the nominated site (Section 5.b.). An existing pier is still in use. The active quarry is a much used research locality in the study of palaeontology and sedimentology and will probably continue to be used as such as long as quarrying ensures fresh exposure. Conservation of a geological profile is included as part of the financed plan for the reestablishment of the quarry after the permission for quarrying expires in 2028.

2.b. History and Development

The steep cliff forming the eastern margin of the Stevns peninsula that projects into the Øresund together with the natural resources of the cliff has caused the nominated Stevns Klint to have a major influence on the cultural history on a local and national scale. This section describes the significant events in history that have affected the evolution of the property and gives an account of its interaction with human-kind.

History of Exploitation

Exploitation of flint from Stevns Klint

From the Epipaleolithic to the earliest part of the Bronze Age, flint was the most important raw material in Northern Europe, and in the nominated area, the layers of limestone and chalk that were rich in flint provided good local resources (Fig. 30). From

the Neolithic, the exploitation of the area was intensified, and towards the end of the Neolithic, c. 4,000 years ago, this had turned into a proper industry, where raw material was exported to distant areas of Scandinavia with no flint.

In the 17th century, flint gained new significance as part of the weapon technology, when the flintlock was invented (Fig. 31). The flintlock continued to be used in Europe up to c. 1850. A production of more than 1.6 million gun stones was recorded from the Stevns Klint area, and local craftsmen were rewarded for the high quality of the product.



Figure 31. Pistol with flintlock and drawing of flintlock in use.

Figure 30. Flint axe and drawing of toolmaker.



Figure 32. Flint oven in Rødvig. The burnt flint was mainly used in faience.

Since then, flint has been used, among other things, in faience and earthenware, and in 1870–1910, flint was burnt in a flint oven in Rødvig (Fig. 32). Today, there is no production of flint from Stevns Klint.



Figure 33. Building stones from Stevns Klint in the ring walls of the castle built in 1167 by the founder of Copenhagen, Bishop Absalon.

Limestone and Construction

Building stones from Stevns Klint are known to have been used from the Middle Ages in churches and military fortifications, and more than 80 stone churches were constructed by means of building stones from Stevns Klint (Fig. 33). The use of limestone in fortifications is known from the first castle in Copenhagen (1167), from Kronborg Castle (1570s) in Elsinore, and from the Citadel in Copenhagen (1624). The stones were cut with axes, and later they were blasted and hewn out of Stevns Klint and transported away by boat.

Gjorslev Manor at Stevns, whose cruciform main building dates back to c. 1400, was also built of limestone from Stevns Klint (Fig. 34). When the owner,



Photo: S. Schenckel

J.B. Scavenius, in the 1790s redistributed land he exchanged property lots along the cliff to secure quarrying rights.

From the mid 19th century, a number of small stone quarries opened on the cliff face. Now building stones was no longer produced by merely shaping stones from blocks that had fallen on the beach but large limestone blocks were loosened from the cliff, and long saws were used to cut the blocks into standardised building stones (Fig. 35). Around this time, the peasants gained increasing independence, and the middle class gained strength, which led to the erection of a large number of buildings such as townhouses and smallholdings. These characteristic buildings can still be seen in large numbers in the Stevns peninsula.



Figure 34. The local Gjorslev Gods: The cruciform main building was built by Bishop Lodehat, the chancellor of Queen Margrethe I around 1400.

Photo: S. Schenckel

Chalk, Ground Lime and Burnt Lime

An increasing demand for lime to be used in mortar, for industrial purposes, and for soil improvement led to the establishment of open quarries towards the end of the 19th century and early 20th century.





Figure 35. Workers in cliff quarry c. 1900.

The first quarry was started in Sigerslev in the northern part of the cliff and in 1922 one plot owner from Boesdal started quarrying limestone at the southern part of the cliff. At the northern part of the cliff by Holtug, quarrying had started in 1919, but soon after, the limited company Faxe Kalk A/S took over quarrying activities, heralding a new era in the production.

In the following years new factory plants were built both in Boesdal and in Sigerslev whereof the latter was later modernised and is still in operation. In the 1970s the quarries at Holtug and Boesdal were closed as part of a streamlining effort and as a result of a declining demand for mortar. In Holtug, the oven and the silo were blown up and all timber buildings were burnt down, whereas the characteristic buildings have been preserved in Boesdal (Fig. 36).

Today, Holtug Kridtbrud has been taken over by the Danish Nature Agency, while Boesdal has been taken over by Stevns Municipality. Both quarries now serve as recreational spaces, but they are also part of the cultural landscape that bears witness to human exploitation of the cliff as a resource and as a workplace.



Figure 36. Limestone ovens at the abandoned quarry Boesdal.

Photo: Jakob Laurrup

NOMINATION OF STEVNS KLINT

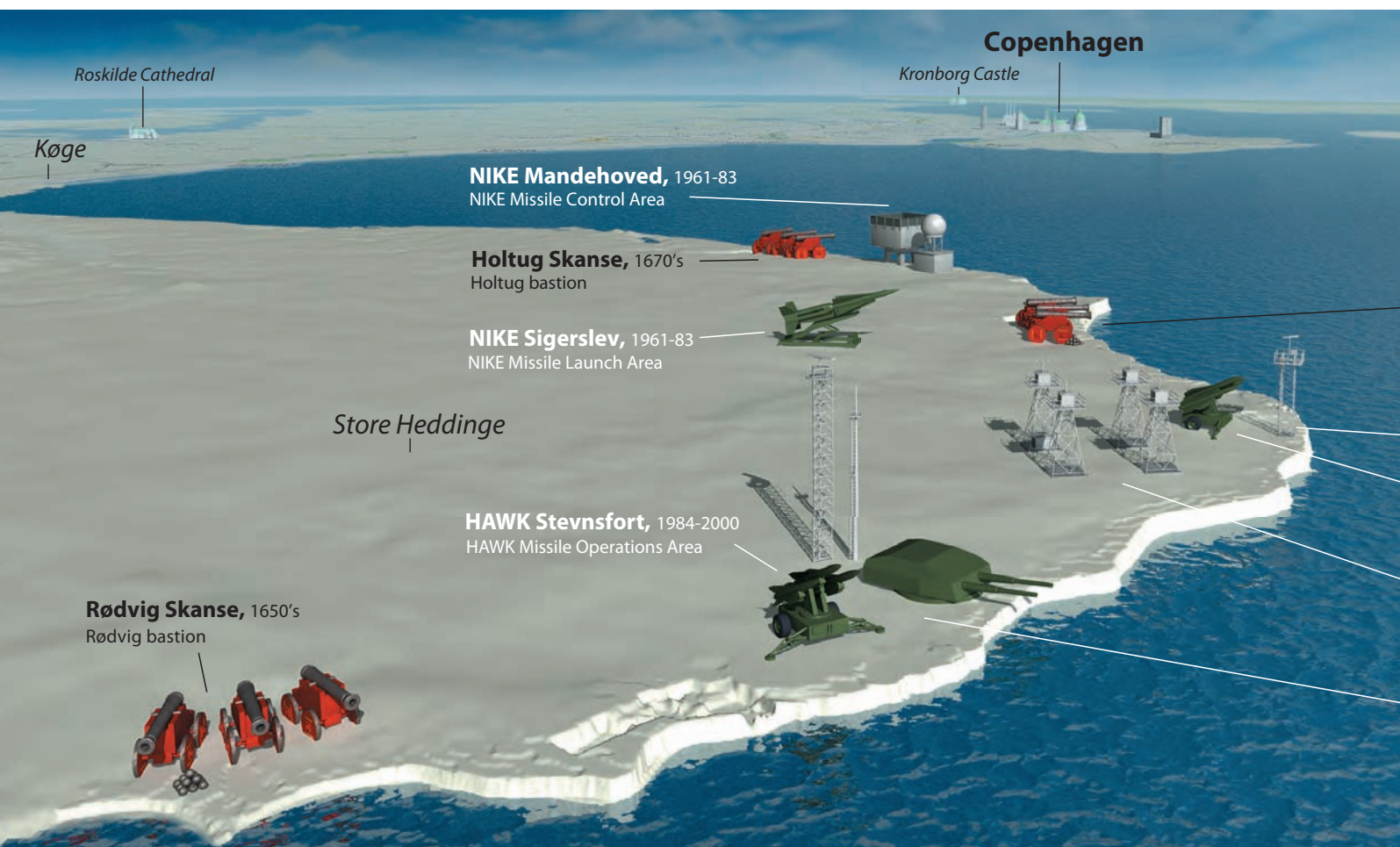


Figure 37. Military installations along Stevns Klint showing the proximity of the capital, Copenhagen.

The Military History of Stevns Klint

The Strategic Significance

Stevns Klint marks the Stevns peninsula as a solid bulwark between the southern part of Øresund and the western part of the Baltic Sea. Øresund is narrowed by the Stevns peninsula so the distance to the coast of Sweden is merely 22 km. Accordingly, Stevns has always played a strategically important role for the control of the passage to the Baltic Sea, and as a first defence against enemies from the east and the south.

Only few traces of defence installations exist from antiquity and early historical times as the cliff in itself formed an almost insurmountable obstacle. However, the renowned Danish bishop Absalon is said to have assembled fleets sheltered by Stevns Klint and to have

collected ballast and sling stones in connection with raids against the pagan Wends on the northern coasts of Germany.

"After peace had been made with Henry, Absalon arrived at Stevns Klint where he loaded his ship with throwing stones, which he picked up along the shore. He was going to use them to defend the castle he had erected in Copenhagen." (14th book by Saxo, page 261) (Saxo: 1160-1208).

The Fortifications

An actual fortification of the area along Stevns Klint was first established during the numerous wars between Denmark and Sweden in the period between



Photos: Jakob Laurrup

Figure 38. The Cold War fortress Stevnsfort with subterranean control room and 150 mm canons.

1596 and 1720. It was feared that a fleet would anchor by Stevns Klint before a possible attack on the capital, Copenhagen, or that the enemy might land soldiers who could attack the capital from the south. Fortifications were established in the 1600s and reinforced and extended during the Great Northern War in 1713 and during the Napoleonic Wars, 1801–14 (Fig. 37). The fortifications, however, were never used in battle.

The waters off Stevns Klint, on the other hand, were the scene of some of the greatest sea battles in the wars between Denmark and Sweden. During the Scanian War in 1677, a great Danish fleet of more than 30 warships anchored off Stevns Klint at Mandehoved, and from here, they attacked a similarly sized Swedish fleet, which tried to force its way into Øresund. The sea battle ended with a significant defeat of the Swedes who

lost eight warships and suffered losses of almost 3,000 wounded, dead and captured. Another battle occurred during the Great Northern War in 1710, when the Danish fleet sought cover by Stevns Klint after a storm and was caught off guard by a large Swedish fleet of 45 ships, which was forcing its way to Copenhagen.

The Cold War

When Denmark became a member of NATO during The Cold War, Stevns Klint became a central element in the Danish defence as a natural consequence of the strategic position and the character of the cliff.

In 1953–56 a large coast-defence fortress, Stevnsfort, was established in order to monitor ship traffic of the



Photo: Jakob Laurrup

the Warsaw Pact through Øresund. More than 1.6 kms of tunnels were dug out underground behind Stevns Klint, where the soft limestone and hard flint layers offered good protection in case of an attack from both conventional and nuclear weapons (Figs 38, 39). A surveillance station was set up to monitor ship traffic, and large canons were placed to provide means of stopping ships. The fortress remained permanently on high alert right up until it was closed in 2000. Through those 45 years, some 10–12,000 Danish soldiers served at the fortress.

In order to contribute in the protection of Copenhagen, three anti-aircraft missile batteries were built along Stevns Klint (Fig. 37). Throughout the period, the batteries remained on high alert, able to shoot within five minutes at any given time.

As something unique, the military facilities from The Cold War have been preserved as complete cultural environments. Today, Stevnsfort and the associated anti-aircraft battery in particular form the basis for the Cold War Museum Stevnsfort, which appears and is

Figure 39. The subterranean Cold War fortress Stevnsfort with 1.6 km of tunnels excavated into the limestone.

presented as a complete, preserved cultural environment, standing exactly as when the armed forces left the fortress in 2000. Work is currently in progress to have the area protected by legislation.

Stevns Klint and the Sea

Stevns Klint is situated at the southernmost part of Øresund, which connects the Baltic Sea with the Kattegat Sea and constitutes the shortest navigation route for sailing between the two waters, and has the character of an international strait that allows foreign ships free passage. Quite a few ships opt for the short route through Øresund, and every day, some 1,200–1,500 ships of every size and from many nations pass Stevns Klint.

The Lighthouses

Along Stevns Klint, the shallow water depth, strong sea currents, and the lack of natural harbours have chal-

Photo: Jakob Laurrup

Figure 40. The two protected lighthouses at Stevns.



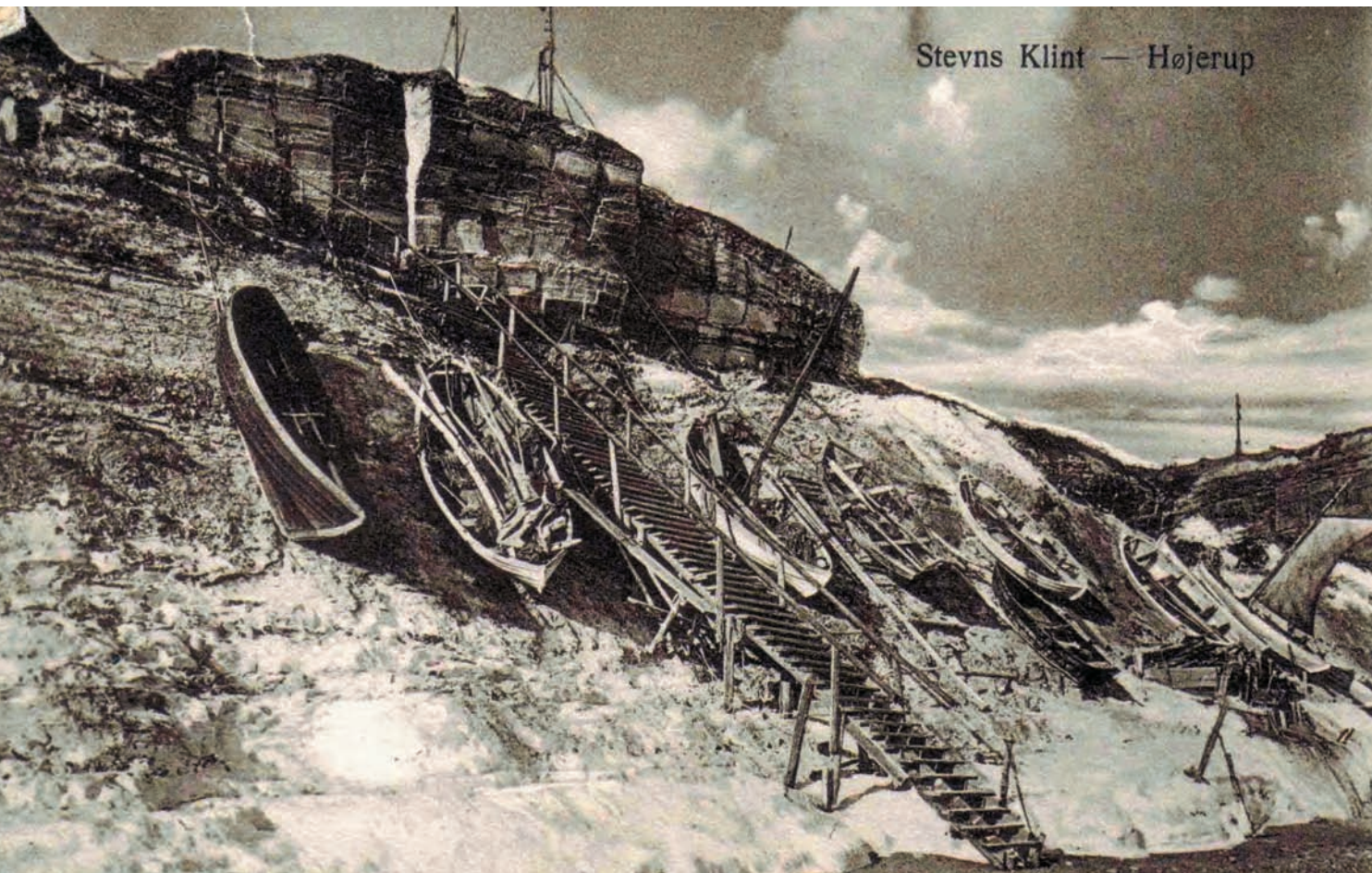


Figure 41. Fishing boats on the cliff. Postcard.

lenced sailing along the cliff. The difficult waters in combination with increasing ship traffic contributed to the decision to build a small lighthouse on the highest point of Stevns Klint (41 m above sea-level) in 1816–18. The lighthouse was replaced by a new 27 m high lighthouse built in 1878 (Fig. 40). Both lighthouses were built of local limestone, and the youngest lighthouse is still in service.

After Denmark entered NATO, the focus on monitoring ship traffic increased, and in 1951, the area around the lighthouses was laid out as a closed military area. A coastguard station was established, which was to register ship traffic in the waters off the cliff. The coastguard station was staffed around the clock until it was closed in 2011. Today the lighthouses and the former military area constitutes a popular recreational site open to the public.

Fishing from Stevns Klint

Inshore fishing has taken place off Stevns, but the cliff has left its mark on fishing, mainly by complicating landing. Harbours were constructed south and north of the cliff at Rødvig and Bøgeskov around the mid 1800s, but fishing grounds were also found in several other places along the cliff. At steep sections of the cliff, the fishermen hoisted the fishing boats up the cliff to prevent them from being crushed on the shore by the surf. Up until the 1930s where motor boats gained ground, it was common to see returning fishermen using winches to pull their boats to safety on the cliff (Fig. 41).

History of Tourism

The dramatic location of the medieval Højerup Church combined with the stunning view of the cliff has made Højerup attractive to painters and the natu-



Photo: P. C. Skovgaard, Højerup Kilde på Stevns Klint, 1842, Statens Museum for Kunst, © SMK Est.

Figure 42. Painting of Stevns Klint by P. C. Skovgaard (1842).

ral centre for tourism at Stevns Klint for centuries (Fig. 42). As early as in the 1840s, the small house of the gamekeeper was transformed into an eatery for visitors to the cliff. In 1920, a national memorial park was established for both locals and tourists, and in 1958, Stevns Museum was built. They are both still in service.

The largest tourist attraction of the area has been the old church, which lost its choir to the sea in 1928 in a dramatic cliff fall (Fig. 43). The fallen church formed a spectacular sight and the first Sunday after the slide,

20,000 people visited the village of Højerup, and even the King paid visit to the site.

The dramatic fate of the medieval church and the beautiful view of the cliff still make Højerup the centre for tourism and will continue to do so in future. However, over the past 30 years, a number of new areas have been opened to the public and developed as tourist attractions, including the abandoned quarries Boesdal and Holtug, the two protected lighthouses, the area at Mandehoved/Flagbanken, and not least the area around the Cold War Museum Stevnsfort.

Figure 43. A view from the protected Højerup Church that lost its choir to the sea in a rockfall in 1928.



3. Justification for Inscription



3.a Criteria under which Inscription is Proposed (and Justification for Inscription under these Criteria)

Stevns Klint is proposed to be inscribed under the criterion (viii) of Paragraph 77 of the Operational Guidelines for the Implementation of the World Heritage Convention (2008), stating that the nominated properties shall:

“Be outstanding examples representing major stages of earth’s history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiogeographic features”.

Stevns Klint is proposed because it is an outstanding example of a major stage in Earth’s history and the record of life: The mass extinction at the Cretaceous–Tertiary boundary.

The Cretaceous–Tertiary boundary marks a severe mass extinction and ecological crisis, and represents a significant shift in life forms between the Mesozoic and Cenozoic Eras. The mass extinction was worldwide, covering all continents and ocean basins, and more than 50% of all species became extinct. Organisms from a broad range of ecological environments were hit by the extinction, and they included marine and continental forms, plants and animals, large and microscopic forms. The most spectacular event was the total extinction of non-avian dinosaurs. The boundary thus marks the transition of life from the Mesozoic Era ruled by land-dwelling dinosaurs and marine reptiles to the life of the Cenozoic Era ruled by a diverse collection of continental and marine mammals, as we know it from the modern Earth.

The Cretaceous–Tertiary boundary thus not only marks a key event for our understanding of the history of life on Earth but also plays an important role in the study of evolutionary concepts. The dramatic Cretaceous–Tertiary boundary interval with its mass extinction, extinction of dinosaurs and large marine reptiles,

and global effects of an asteroid impact thus has a very high value in the communication of evolutionary concepts highlighted as the overarching theme for geological World Heritage Sites presented by Wells (1996) and followed by Dingwall *et al.* (2005).

Extinction is a key aspect in the understanding of evolution and the discussion about the future life on Earth. Normal background extinction happens at all times with an average of 5–10% of all species disappearing every million years. Mass extinction in contrast is dramatic and includes the extinction of many species and higher biotic groups, representing different ways of life and occupying differing habitats. Mass extinction occurs in a short period of time and in numbers that are way above the ordinary background extinction.

Life has experienced several mass extinctions. The mass extinction at the Cretaceous–Tertiary boundary rates among the top three mass extinctions in the history of life, and to most people, it is the most spectacular as the dinosaurs and large reptiles were among the famous victims, and as it was associated with an asteroid impact. It was research on the Cretaceous–Tertiary boundary that led to the development of the revolutionary hypothesis that asteroid impacts have a major influence on life on Earth.

The impact hypothesis came as a marked contrast to the traditional gradualistic approach to modern geology that had been the key to understanding geology since it was founded by the British geologist C. Lyell in the 19th century. The gradualist approach uses modern processes in order to understand geological processes and events exemplified by the expression “The present is a key to the past”. And as no person had experienced an asteroid impact causing mass extinction, the catastrophist hypothesis was considered highly controversial when it was first suggested in 1980 and it has been intensely debated in subsequent years. Today, more than three decades later, the influence of impacts on life on Earth is no longer regarded as controversial.

NOMINATION OF STEVNS KLINT



Figure 44. The exceptionally well-exposed boundary section at Stevns Klint.

Photo: Peter Warmøe-Moos

The focus of the debate is now on the effect of asteroid impact in itself and in combination with other factors such as large-scale volcanism, climate change and sea-level fall.

It is concluded that the Cretaceous–Tertiary boundary event conforms to the major recommendations of Wells (1996) and Dingwall *et al.* (2005) for geological World Heritage sites, and the event is thus proposed to be included on the list. As documented in the Description (Section 2) and the Comparative Analysis (Section 3.c), Stevns Klint is outstanding among Cretaceous–Tertiary boundary sections and is characterised by an exceptional exposure of the boundary layers making it possible to study the biotic evolution across

the boundary (Fig. 44). The cliff section exposes a complete stratigraphic record of continuous deposition of fossiliferous chalk and limestone in a marine setting across the boundary, and the well-defined boundary layer is readily visible even to the inexperienced eye as a thin line of black clay (Fig. 45). Stevns Klint is also an exceptional location for the study of chalk sedimentation in various styles and sequence boundaries in a pelagic carbonate setting. The 15 km profile is exceptionally helpful in this regard, as is the change in orientation from N–S near Højerup to E–W at Rødvig. These values together with the long and still ongoing scientific interest in the site make Stevns Klint an outstanding example of the boundary between the Cretaceous and the Tertiary Periods.

Figure 45. Visitor pointing out the boundary clay marking the mass extinction.



Photo: Tove Damholt

The Thematic Approach of World Heritage Natural Sites

A thematic approach to geological World Heritage Natural Sites was presented by Dingwall *et al.* (2005). This work recommends major thematic areas as a broad conceptual framework to provide a basis within which the nominated World Heritage natural properties can be examined in order to assess the claim to Outstanding Universal Value from the viewpoint of science and conservation.

Stevns Klint is proposed to be included in three of thirteen thematic themes proposed for criterion (viii) by Dingwall *et al.* (2005):

STRATIGRAPHIC SITES. Rock sequences that provide a record of key Earth history events.

Stevns Klint obviously qualifies as a Stratigraphic Site providing a record of a key Earth history event, the mass extinction event at the Cretaceous–Tertiary boundary. Stevns Klint additionally plays a key role in a major discovery related to our overall understanding of processes significantly influencing life on Earth, the asteroid impact hypothesis. No sites covering the complete Cretaceous–Tertiary boundary succession are

presently on the list and no sites covering mass extinction events are presently on the list. The Canadian World Heritage Site, the Dinosaur Provincial Park contains an outstanding number and variety of Cretaceous dinosaurs. However, the site does not cover the extinction event at the Cretaceous–Tertiary boundary. Stevns Klint thus fulfills a part of the theme that is presently not represented on the World Heritage List.

METEORITE IMPACT. Physical evidence of meteorite impacts, and major changes that have resulted from them, such as extinctions.

Stevns Klint qualifies as a Meteorite Impact Site showing evidence of global mass extinction caused by an extraterrestrial impact. One existing World Heritage Site, the Vredefort Dome in South Africa is registered as a Meteorite Impact Site. This site is an impact crater and demonstrates the physical evidence of an asteroid impact in contrast to Stevns Klint that demonstrates the global scale effect of a large extraterrestrial impact and major changes including mass extinction associated with the impact. Stevns Klint thus fulfills an explicit part of the theme that is presently not represented on the World Heritage List.



NOMINATION OF STEVNS KLINT

FOSSIL SITES. The record of life on Earth represented by the fossil record.

It could well be argued that Stevns Klint represents a Fossil Site. The fossil record at Stevns Klint represents a succession of communities characteristic of the marine Late Cretaceous and Early Tertiary Periods. The species diversity is very high for nanno-, micro-, meso- and macrofossils, and most marine fossil groups are represented. The state of preservation is generally very good and the site is of outstanding importance for the study of the nature of mass extinctions and the tempo and mode of the subsequent recovery, and thus for understanding of key evolutionary problems. No Fossil sites covering the Late Cretaceous–Early Tertiary time intervals and the complete boundary between these two periods are presently on the List.

Based on the Operational Guidelines for the Implementation of the World Heritage Convention (2008), the recommendations of Dingwall *et al.* (2005), and the comparative analysis (Section 3.c), Stevns Klint is proposed to be inscribed as a World Heritage Site under criterion (viii) as it represents a truly outstanding example of a major stage of Earth's history, including the record of life and demonstrates the global effect of an extraterrestrial impact.

3.b Proposed Statement of Outstanding Universal Value

Stevns Klint (klint = cliff) is a 15 km long scenic coastal cliff one hour drive south of the Danish capital Copenhagen. Stevns Klint illustrates the most spectacular global mass extinction event in the history of Earth: The Cretaceous–Tertiary boundary. The mass extinction that occurred 65 million years ago is particularly spectacular due to its association with an asteroid impact and because it marks the extinction of more than half of all species, including land-living dinosaurs and large marine reptiles.

Stevns Klint forms the best exposed Cretaceous–Tertiary boundary section in the world with the excep-

tional boundary layer being easily recognisable immediately beneath a pronounced topographic overhang, which separates the underlying soft Cretaceous chalk from the overlying, harder Tertiary limestone. The thin black boundary clay layer found in the up to 40 m high, white cliff clearly marks the fall in primary production and makes the exceptional boundary layer visible even to the inexperienced eye.

Criterion viii: Stevns Klint is an outstanding example representing a major stage in Earth's history and the record of life: The mass extinction at the Cretaceous–Tertiary boundary. An example of the major changes caused by an asteroid impact is presently not found on the World Heritage List and based on the combination of quality of exposure, fossil diversity and scientific impact the Stevns Klint site stands out from the more than 500 registered localities globally comprising the spectacular catastrophe at the Cretaceous–Tertiary boundary.

The nominated site has played a significant role in the international study of the causes of mass extinction and the effect of extraterrestrial impact on life on Earth as it was among the original study localities that first led scientists to the hypothesis of an asteroid impact as a cause for mass extinction and is thus of high value for the understanding of key evolutionary problems.

The key to the integrity of Stevns Klint lies in the completeness of the boundary section, the good preservation of rich fossil assemblages, and in the high quality of the outstanding exposure of high permanency and great lateral extent. The site boundaries are defined to encompass the extent of the continuous exposure that is of utmost importance to reveal any variation in depositional environment and thus to allow filtering of local signals recorded in the environment from the global signal of mass extinction. The intense scientific interest adds to the integrity as the more than 200 scientific papers provide a high degree of documentation of the site.

The legal protection of the nominated area and its buffer zone is adequate, and national and municipal legislation accords protection of future exposures in a buffer zone landward of the property. The property is well managed and resourced, with a comprehensive management plan in place and resources for its implementation. Key management issues include presenting the geological site and its significance, and managing the expected increase in number of visitors to the property. Natural wave erosion secures high quality exposure for at least 20,000 years.

3.c Comparative Analysis (incl. State of Conservation of Similar Properties)

Prerequisites for Cretaceous–Tertiary Boundary Sections

The Cretaceous–Tertiary boundary reflects a spectacular global event, and the wish to understand this dramatic period in the history of life has made the Cretaceous–Tertiary boundary sediments among the most intensively investigated deposits in the geological record.

The intense interest has resulted in scientific papers counted in thousands. The global nature of the event and the intense interest in the boundary has also resulted in the search for localities worldwide, and today more than 500 Cretaceous–Tertiary boundary sites have been recorded around the world (Kiessling and Baron-Szabo 2004).

A comparative analysis of the sites covering the Cretaceous–Tertiary boundary was undertaken in a comprehensive study by Dr A. M. Sørensen appended in full in a separate volume (Appendix 6) and referred to in this nomination document (Fig. 46).



Figure 46. The comparative study by Dr. A. M. Sørensen is presented in full in Appendix 6 as a separate volume.

With more than 500 known Cretaceous–Tertiary boundary sites it is necessary to produce a shortlist for the comparative analysis. For this purpose, three prerequisites were defined and only sites that met these were analysed in greater detail. The three prerequisites are defined to ensure that sites examined in the comparative analysis tell the complete story of the biotic turnover across the Cretaceous–Tertiary boundary and include traces of the extraterrestrial impact.

Cover: Charlotte Clante







NOMINATION OF STEVNS KLINT

K/T boundary sites	Country	Scientific impact	Environment / depth	Location
El Kef	Tunisia	97	<i>Upper bathyal 300–500 m</i>	Valley
Stevns Klint	Denmark	53	<i>Epicontinental sea >100 m</i>	Coastal cliff
Hell Creek	Montana, USA	53	<i>Terrestrial</i>	Valleys
Caravaca	Spain	45	<i>Middle bathyal 600–1000 m</i>	Valley
Raton Basin	New Mexico USA	25	<i>Terrestrial</i>	Road cut
Brazos River	Texas, USA	24	<i>Middle – outer shelf <100 m</i>	River bank
Beloc	Haiti	22	<i>Deep marine 1500–2000 m</i>	Road cut
Mimbral	Mexico	22		Stream bank
Agost	Spain	22	<i>Middle bathyal</i>	Road cut
Gubbio	Italy	19	<i>Lower bathyal 1500–2500 m</i>	Road cut
Hokkaido	Japan	17	<i>Upper bathyal (300–600 m) shallowing to 150–300 m</i>	Stream bank
Nye Kløv	Denmark	11	<i>Epicontinental sea >100 m</i>	Abandoned quarry
Seymour Island	Antarctica	11	<i>Shallow mid shelf</i>	Valleys and coastal cliff
Elles	Tunisia	11	<i>Middle to outer neritic shelf</i>	Valley
Flaxbourne River	New Zealand	11	<i>Middle bathyal</i>	Quarry
Ain Settara	Tunisia	11	<i>Middle to outer neritic shelf</i>	Along a channel
Woodside Creek	New Zealand	10	<i>Upper bathyal</i>	Creek

Table 2. Cretaceous–Tertiary boundary sites that meet the prerequisites, i.e. are complete across the boundary, have a scientific impact of more than ten references on either Web of Science or GeoRef, and have a boundary layer lithology different from the surrounding lithologies. The scientific impact is found by searching for acronyms used for the Cretaceous–Tertiary boundary together with the site name. The highest score found on either Web of Science or GeoRef is listed in the table. Much more has been published on several of the classical sites but the same citation databases have been used for all methods for reasons of comparison.

The prerequisites the sites should fulfil are:

- The succession should be complete across the boundary and should include the latest Cretaceous and the earliest Tertiary strata in order to represent the entire event, the nature of the mass extinction, and the subsequent recovery of life after the extinction.
- The Cretaceous–Tertiary boundary site should be well studied and described, allowing comparison.
- The boundary layer should be lithologically different from the underlying Cretaceous sediments and the overlying Tertiary sediments, and should include the characteristic enrichment in iridium and other rare elements.

More than 500 Cretaceous–Tertiary boundary sites were tested in order to produce a list of the exposed sections fulfilling the prerequisites. For this purpose, an already existing comprehensive database (KTbase) was examined. The KTbase was originally designed to evaluate the causes and mechanisms of the Cretaceous–Tertiary boundary event (Kiessling and Claeys 2001; Kiessling and Baron-Szabo 2004) and is not publically accessible, but the filtering of the database was generously conducted by Professor W. Kiessling (Natural History Museum, Berlin).

3. JUSTIFICATION FOR INSCRIPTION



Figure 47. Map showing locations of Cretaceous–Tertiary boundary sites meeting the three prerequisites and included in the comparative analysis.

The test of the more than 500 Cretaceous–Tertiary boundary sites resulted in 43 boundary sites fulfilling two of the prerequisites by showing exposed sections complete across the boundary and by including the presence of a boundary layer enriched in iridium and other elements (Table 2). Subsequently, the 43 sites together with eight possibly complete localities were tested for their scientific impact by making searches of acronyms which have all been used to describe the boundary together with the locality name in the standard databases Web of Science and GeoRef. Of the 51 Cretaceous–Tertiary boundary sites analysed for scientific impact, 17 sites turned out to be well described with more than 10 scientific papers in either of the databases (Table 2).

Comparison and Evaluation of the Cretaceous–Tertiary Boundary Sites

The 17 Cretaceous–Tertiary boundary sites fulfilling the three prerequisites cover a range of depositional

environments and are found in 13 countries on six continents (Fig. 47). The sites were analysed in detail in the comparative analysis of potential Cretaceous–Tertiary boundary sites. The detailed descriptions of the 17 sites are presented in the comparative analysis (Appendix 6).

An additional number of issues have to be addressed in order to compare the 17 sites with respect to their potential as World Heritage Site. Criteria for selecting palaeontological World Heritage Sites have been discussed in a number of publications (Cloutier and Lelièvre 1998; IUCN 1994; Wells 1996; Falcon-Lang 2002; Dingwall *et al.* 2005). However, most of these discuss the criteria for fossil sites, limiting the relevance for a stratigraphic and meteorite site. The prime focus for evaluating stratigraphic sites is the integrity of the sites including the fossil diversity.



NOMINATION OF STEVNS KLINT

Falcon-Lang (2002) defines three major categories for the comparative analysis of Pennsylvanian fossil sites. These categories are modified for the comparative analysis of Cretaceous–Tertiary boundary stratigraphic sites by shifting the focus from the fossil archive to the nature and quality of the rock section.

The comparative analysis focuses on three major issues:

- **The nature and quality of the rock section itself (the integrity)**
The site should be of high quality and permanency and contain a clearly defined stratigraphic section.
- **Fossil record of biodiversity**
The site should contain high fossil diversity, representing the broadest possible range of major taxonomic groups.
- **Fossil record of biodiversity**
The site should have high quality for scientific studies.

The Nature and Quality of the Rock Section Itself (The Integrity)

The nature and quality of the rock section is essential to the integrity of the site. The integrity regards the extent to which the site includes all elements necessary to express the Outstanding Universal Value of the stratigraphic interval.

The quality of the boundary layer is of utmost importance for the integrity. The 17 sites included in the detailed comparative analysis all have a complete boundary section, including the characteristic enrichments of iridium. The quality of the boundary varies, however, and the purpose of the comparative analysis is to perform a detailed evaluation of the quality of the section.

In order to communicate the boundary to visitors of the site it is essential that the boundary layer is easily recognised also for the inexperienced eye, and the visibility is evaluated as part of the analysis. The lateral extent of the boundary is another essential parameter for the integrity. Laterally extensive sections make it possi-

ble to detect lateral variations and thereby to perform the essential separation between local and global signals of the rock record. The boundary layers are generally of limited thickness and the lateral extent of the boundary layer is thus important to provide more study material, such as fossils and impact material without the risk of oversampling. Laterally extensive sections also offer greater opportunities to establish sustainable protection of the site and thereby to provide sections for further studies.

The degree of erosion is another important factor for preserving the integrity of a site, and in contrast to most preservation requirements, a high degree of erosion is preferred for this type of geological site (e.g. Falcon-Lang 2002). Exposures found in abandoned quarries, road cuts, valleys and creeks commonly have no or only limited erosion and as a consequence are likely to suffer from overgrowth by vegetation. Exposures along streams and rivers may have continuous erosion keeping the site clean, but these exposures vary as part of the nature of this type of erosional process, resulting in a low permanency of the site, and additionally, the watercourses may dry up. Coastal cliffs are subject to natural continuous erosion, which will keep a high exposure and permanency of the sites, since there is no risk of oversampling or overgrowth. Erosion and lateral extent is evaluated as part of the integrity in the comparative analysis.

In the comparative analysis, three elements regarding the integrity of the sites were evaluated: the visibility of the boundary layer, the lateral extent of the boundary section, and the degree of exposure and permanency of the site.

The comparative analysis illustrates that the nominated Stevns Klint site, together with five other sites, contains an easily recognised boundary layer. Regarding the lateral extent, the Stevns Klint site ranks highest together with Hell Creek, Brazos River and Seymour Island with a lateral extent of more than 1 km; Stevns Klint and Hell Creek have a lateral extent of more than 10 km. Regarding the permanency of the

3. JUSTIFICATION FOR INSCRIPTION



Site	Visibility of boundary layer			Lateral extent				Quality of exposure			TOTAL
	Guide needed	Hard to recognize	Easy to recognize	Less than a few metres	Few metres	100 m —1 km	> 1 km	Quarry and road cut	River cut	Coastal cliff	
Stevns Klint			4				4			4	12
Seymour Island		2					4			4	10
Hell Creek		2					4	1			7
Brazos River		2					4		2		8
Caravaca			4		2			1			7
Ain Settara			4			3			2		9
El Kef	1					3		1			5
Agost			4	1				1			6
Mimbral		2				3			2		7
Raton Basin		2			2			1			5
Beloc		2				3		1			6
Nye Kløv		2			2			1			5
Woodside Creek			4		2			1			7
Elles		2				3		1			6
Gubbio			4	1				1			6
Hokkaido		2		1					2		5
Flaxbourne River	1				1			1			3

*Raton Basin: Several small sections over several kilometres.

Table 3. Table showing the evaluation of the integrity of the 17 sites included in the detailed comparative analysis. Visibility of the boundary layer is rated on a scale with easy visibility even to the inexperienced eye giving the maximum of 4 points and sections where a guide is needed to point out the layer is given 1 point. The lateral extent of the boundary section is rated on a scale where sections more than one kilometre is given a maximum of 4 points and sections of less than a few metres is given 1 point. The quality of the exposure is rated based on the type of the exposure based on literature where sea cliff with ongoing erosion is given the maximum point of 4, and quarries and road cuts a minimum of 1 point. The total ranking includes an evaluation of the visibility of the boundary layer, the lateral extent of the boundary section and the quality of the exposure evaluated as the degree of exposure and permanency of the site.

site, only Stevns Klint and Seymour Island (in part) are coastal cliffs and are ranked highest.

The analysis shows that Stevns Klint ranks higher than all other sites when the combined quality of the rock section is evaluated based on the visibility of the boundary layer, the lateral extent of the boundary section, and the degree of exposure and permanency of the site (Table 3, Fig. 48). It can be concluded that the integrity of Stevns Klint is the best of all Cretaceous–Tertiary boundary sites.

Fossil Record of Biodiversity

The fossil record tells the evolutionary story of the biota across the Cretaceous–Tertiary boundary. The more biotic groups present, the more studies can be

made on the timing of extinction, the degree and selectivity of extinction, survivorship, and recovery after extinction. Microfossils are of utmost importance as they commonly occur in large numbers even in small samples. All kinds of fossils are included in this criterion, as sites with a high number of groups tell a more complete story of the extinction event. To compare the sites, the diversity of the major taxonomic groups present in each site is calculated, including the micro- and macroflora, the micro- and macrofauna and trace fossils.

The Seymour Island site ranks highest with all major groups being present (Table 4). The Stevns Klint site ranks second, together with three other sites, due to the absence of macroflora. Stevns Klint together with

NOMINATION OF STEVNS KLINT



Figure 48. The boundary section at the nominated Stevns Klint site with the dark boundary layer clearly visible.

four other sites thus has a high score in fossil diversity. On a more detailed level, the boundary section at Stevns Klint additionally ranks high in species diversity, fossil density and state of preservation although there has been some dissolution of small calcareous-shelled fossils in the Fiskeler Member where only “robust” foraminifera are present. It is concluded that Stevns Klint has a very good fossil record (Appendix 3.1, Table 4).

Scientific Impact of Site

This criterion evaluates the present scientific impact of the site in order to quantify the degree to which the site has been investigated and includes a measure of the possibility of future studies. The Cretaceous–Ter-

tiary boundary has been studied by a wide spectrum of methods, including sedimentological studies of the lithology and physical structures of the boundary deposits and a huge amount of studies of a variety of floral and faunal groups, representing both marine and continental realms. In addition to these methods, a vast spectrum of geochemical and mineralogical analyses has been undertaken, such as clay mineralogy, stable isotope studies, and studies of trace elements, including iridium and other platinum group elements.

Data on the present scientific impact were collected from the online databases Web of Science and GeoRef (Table 5). The search gives an estimate of the amount of studies that have been carried out on the sites re-

3. JUSTIFICATION FOR INSCRIPTION



Fauna						
	Micro fauna	Micro flora	Macro fauna	Macro flora	Trace fossils	Total
Stevns Klint	2	2	2		1	7
Seymour Island	2	2	2	2	1	9
Hell Creek		2	2	2	1	7
Brazos River	2	2	2		1	7
Caravaca	2	2	1		1	6
Aïn Settara	2	2	2			6
El Kef	2	2	1		1	6
Agost	2	2	1		1	6
Mimbral	2			2	1	5
Raton Basin		2	2	2		6
Beloc	2	2				4
Nye Kløv	2	2	2		1	7
Woodside Creek	2	2				2
Elles	2	2			1	5
Gubbio	2	2				4
Hokkaido	2					2
Flaxbourne River	2	2				4

Table 4. The fossil diversity of the 17 selected boundary sites. Presence of a major biotic group rates a maximum of 2 points, presence in insignificant numbers rates 1 point. Trace fossils are regarded as less important compared to body fossils, and presence of trace fossils rates a maximum of 1 point.

garding the boundary event, but the search to some degree includes papers that only refer to the site without actually representing work done on the site. As an example, the El Kef site, which is the Global Stratotype Section and Point (GSSP) for the Cretaceous–Tertiary boundary, is cited in many publications without any research actually having been undertaken at the site. For all localities, it may be stated that older works and other works not represented in the selected online databases are not included in the list. This is particularly the case with classical, easily accessible sites. However, the applied method is still regarded as the best for comparison of the scientific impact of the sites.

The analysis of the scientific impact shows that the statorype El Kef site is the most cited site and that Stevns Klint is ranked second together with the Hell Creek site.

The number of scientific work published forms part of the potential for future research together with the

Scientific impact						
	10-19	20-29	30-49	50-79	80+	Total
Stevns Klint				4		4
Seymour Island	1					1
Hell Creek				4		4
Brazos River			3			3
Caravaca			3			3
Aïn Settara	1					1
El Kef					5	5
Agost		2				2
Mimbral		2				2
Raton Basin			3			3
Beloc		2				2
Nye Kløv	1					1
Woodside Creek	1					1
Elles	1					1
Gubbio	1					1
Hokkaido	1					1
Flaxbourne River	1					1

Table 5. Scientific impact of the 17 boundary sites.

quality of the site as evaluated above. The accessibility of the site is an additional factor. The accessibility of the 17 sites has been evaluated, and thirteen of the seventeen sites, including Stevns Klint are easily accessible (Appendix 6). An analysis of the potential for future scientific work, including these factors does not affect the total sum of the comparative analysis and is excluded from the tables for reasons of clarity.

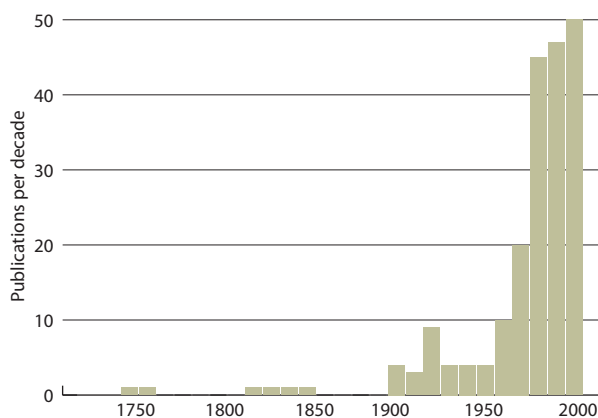


Figure 49. History of scientific publication on Stevns Klint. Stevns Klint is not only a classical study locality but in the last decades the site has received increasing scientific interest reflected in numerous papers following the seminal study of Alvarez *et al.* 1980.



NOMINATION OF STEVNS KLINT

It is concluded that Stevns Klint not only ranks among the three most studied boundary sections in the world but also has a very high potential for further studies based on the high quality exposure with very easy access for scientists, and the history of research (Fig. 49).

Summary and Conclusion of the Comparative Analysis

The comparative analysis of Cretaceous–Tertiary boundary sites around the world was undertaken in order to evaluate their potential as a World Heritage Site. Of the more than 500 Cretaceous–Tertiary boundary sites recorded worldwide, only 17 meet the three prerequisites of completeness of the succession across the boundary, scientific documentation, and the presence of a boundary layer that is enriched in iridium and other elements, considered to be mainly or partly of impact origin.

The 17 sites have been analysed with a focus on three major issues: the nature and quality of the rock section itself (the integrity), the fossil record of biodiversity, and the scientific impact of the site.

Site	Integrity	Fauna	Scientific impact	Total
Stevns Klint	12	7	4	23
Seymour Island	10	9	1	20
Hell Creek	7	7	4	18
Brazos River	8	7	3	18
Caravaca	7	6	3	16
Ain Settara	9	6	1	16
El Kef	5	6	5	16
Agost	6	6	2	14
Mimbral	7	5	2	14
Raton Basin	5	6	3	14
Beloc	6	6	2	12
Nye Kløv	5	7	1	12
Woodside Creek	7	2	1	12
Elles	6	5	1	11
Gubbio	6	4	1	11
Hokkaido	5	2	1	8
Flaxbourne River	3	4	1	7

Table 6. Cumulative score of the comparative analysis.

The nominated Stevns Klint site reaches the maximum total score in the comparative analysis with a total of 23 points (Table 6). The Stevns Klint site ranks first in one of the three major issues addressed and ranks second in the latter two: the fossil diversity of higher taxonomic groups and scientific impact.

It should be noted that the measure on diversity has been performed on higher taxonomic groups. Comparison of diversity on species level would place Stevns Klint far above Seymour Island in fossil diversity (see Appendix 3.1). The biotic assemblage is unique at the Stevns Klint site, as it includes rich benthic micro-, meso- and macrobiota as well as a planktonic microbiota, which expand the understanding of the nature of invertebrate mass extinction and subsequent recovery and evolution after the extinction event. A rich invertebrate fauna is rarely found at other marine sites and has only been studied in any detail at Stevns Klint, Brazos River, Nye Kløv and Seymour Island.

Second in the cumulative scores is Seymour Island with a score of 20 points. The Seymour Island site ranks highest in the fossil diversity criterion, including all of the major biota groups, including macroflora preserved, but the boundary layer is not easily recognised and the scientific impact of the site is low. Additionally, the site is difficult to access, as it is located in Antarctica. Hell Creek and Brazos River both score 18 points. In Hell Creek, the boundary layer is exposed in a valley and may therefore be covered by vegetation and scree and become even more difficult to find or it may disappear in the future. The Brazos River boundary layer is exposed on a river bed and riverbank and has a higher potential for continuous erosion, but at both sites, the boundary layer is not always easily recognised and there is confusion as to which bed actually represents the boundary. The stratotype locality El Kef would not be suited as a WHS as the boundary layer is difficult to find, access is difficult, and the site is endangered by oversampling and agricultural encroachment, and will probably not remain for future generations of humanity.

The classical Cretaceous–Tertiary boundary site at Stevns Klint is not only qualified as the best candidate for World Heritage based on the criteria in the comparative analysis, but also stands out from all other sites with its scenic coastal position.

Cretaceous–Tertiary Boundary →



NOMINATION OF STEVNS KLINT



Stevns Klint is a high-quality boundary site for scientists, students, schools, amateur geologists, and the general public.

This comparative analysis documents that the nominated Stevns Klint site stands out from all other sites when evaluated for the combination of quality of exposure, fossil diversity and scientific impact.

Additionally Stevns Klint is a classical geological site. It is the type locality in the original definition of the Danian, the earliest age in the Tertiary Era (Desor 1847), and was one of the first two iridium discovery localities, leading to the formulation of one of the most important hypotheses in modern geology, involving asteroid impacts dramatically influencing life on Earth (Alvarez *et al.* 1980). Stevns Klint is therefore not only a classical stratigraphical boundary locality but also a key locality in the ongoing studies of the Cretaceous

–Tertiary boundary, and international researchers have flocked to the site to sample the famous iridium-rich boundary layer and collect samples for the study of stable isotopes, mineralogy, biomarkers, macro- and microfauna and nannoflora across the boundary.

It is concluded that the Stevns Klint site has outstanding universal value and is the best candidate for a Cretaceous–Tertiary boundary site on the World Heritage List.



Photo: Stein Lemmer Jakobsen

Test and long delicate spines of a regular sea urchin illustrating the good preservation of fossils from the Stevns Klint section.

3.d Integrity

The Extent to which the Property Includes all Elements Necessary to Express its Outstanding Universal Value

The key to the integrity of Stevns Klint as a World Heritage Site lies in the completeness of the boundary section, the good preservation of rich fossil assemblages, and the intense scientific interest, leading to a high degree of documentation of the site, and in the high quality of the outstanding exposure of high permanency and great lateral extent.

The completeness of the boundary section and the well-preserved fossil record is of utmost importance to the integrity of the site. At Stevns Klint, the boundary is complex but well documented and offers one of the

most expanded Cretaceous–Tertiary sections worldwide, displaying all known biozones.

The boundary clay at Stevns Klint shows all the characteristics of a boundary layer distal to the impact site, including the change in lithology from chalk to black clay, illustrating the dramatic decrease in primary production, and the reddish layer with the iridium anomaly, reflecting the asteroid impact.

The species diversity is very high for nanno-, micro-, meso-, and macrofossils, and most marine fossil groups are represented. The state of preservation is generally very good, especially in the Maastrichtian chalk and the boundary layers, whereas those occurring in the Danian bryozoan limestone commonly are fragmented or compressed.

NOMINATION OF STEVNS KLINT



Figure 50. Area of bryozoan mound exposure on the sea floor. The mounds were mapped out by Bjerager and Surlyk (2007) and provide information about the 3D geometry of the mounds.

The extent of the continuous exposure is of utmost importance to reveal any variation in depositional environment and thus to allow filtering of any local signal recorded in the environment from the global signal. The integrity of the Stevns Klint site is documented through numerous scientific papers focusing on the understanding of the small- and large-scale sedimentary structures (Section 7.e) and through the mapping of the entire cliff section (Surlyk *et al.* 2006) (Appendix 3.2). Constant erosion of the cliff ensures fresh exposures of this basal feature of the outstanding universal value, and as the strata continue landwards behind the cliff high quality exposures are secured for at least 20,000 years (See section 4.a and Appendix 5). The status as a classical boundary site combined with the high quality of the exposure has made Stevns Klint a preferred study area, and virtually all scientists work-

ing with the Cretaceous–Tertiary boundary have visited the site. The large amount of work performed there not only makes it a classical site but also makes it a highly interesting area for future studies.

The Site Boundaries

The nominated property at Stevns Klint is defined to encompass the representation of the Cretaceous–Tertiary boundary. The 15 km long and up to 41 m high white sea cliff forms the major part of the nominated property with the addition of a limited number of smaller areas adding to the perception of the property. Landwards, the site boundary is defined at the top of the cliff by the cliff break and seawards, the boundary is defined by the shoreline (Fig. 2). Inclusion of the beach secures that rocks falling from the cliff are still within the core area and the boundary strata are com-



Figure 51. Bryozoan limestone in the tunnels of Stevnsfort. The 1.6 km long tunnel sections provide good 3D exposures of the bryozoan mounds outlined by the black flint layers.



Figure 52. The exposure in Boesdal provides a fine example of an externally symmetrical but internally asymmetric bryozoan mound.

Photo: Jakob Laurrup

only exposed on the beach. The shoreline is defined by 0 m of the Danish national altitude reference system, DVR90. The definition of the major boundaries with reference to the cliff face and shoreline ensures that the boundaries will include the nominated property despite the continuously ongoing erosion.

The nominated cliff area displays the lateral variation and the total of a 55 m thick stratigraphical section across the boundary and including the Cretaceous–Tertiary boundary.

A diverse set of exposures are included as they add to the understanding of the Danian bryozoan mounds. The different orientation of the cliff on several scales gives a good 3D impression of the strata.

In an area at Stevnstfort in the southern part of the cliff, the seafloor exposes the Danian bryozoan mounds allow map-view of these large-scale structures (Fig. 50). Just landwards of this area, the 1.6 km long network of tunnels of the Cold War fortress Stevnstfort adds 3D exposures of the bryozoan mounds (Figs 50, 51). A few kilometres further south in the abandoned Boesdal quarry, a small exposure adds a fine example of an externally symmetrical but internally asymmetric bryozoan mound (Fig. 52). The abandoned quarry at Holtug in the northern part of the cliff displays an exposure of muddier, more chalk-like deposits characteristic of the Danian of the northern part of the cliff (Fig. 53). The exposures on the seafloor, in the tunnels of Stevnstfort, and in the abandoned quarries Boesdal and Holtug are included in the core area.

3. JUSTIFICATION FOR INSCRIPTION



Figure 53. The boundary layer is exposed in the abandoned Holtug quarry that also provides good exposure of the muddy Danian limestone characteristic of the northern part of the cliff.

In the working limestone quarry at Sigerslev, the activity is now restricted to the area behind the cliff. The activity produces exposures relevant to scientific studies of the chalk, but the exposures are temporary only as they are part of the production area and most will not be preserved. The quarry is therefore not included in the nominated area. However, as part of the regulations, a geological profile results from the production, and when the production stops it will be relevant to include this profile in the core area.

The Extent to which the Property is Affected by Human Activities

The nominated property comprises an area of actively eroding coastline, which is largely inappropriate for development, and today national legislation serves to protect the cliff from future activities in conflict with

the protection of the outstanding universal value. More than 6,000 years of exploitation for natural resources related to the nominated area are described in detail in Section 2.b. Today, the activities affecting the property have ceased, and the traces are slowly disappearing as a result of the natural wave erosion.

Today, the nominated area only displays traces of human activities as described in detail in Section 4.b (i). The buffer zone and the core area of the nominated property have been designated to keep pace with the natural processes of erosion and to ensure conservation of the integrity of the property from the perspective of World Heritage.

Photo: Jakob Laurup



Figure 54. Coastal erosion protects the profile from overgrowth and erases traces of last century quarrying on the cliff face.

4. State of Conservation and Factors Affecting the Property



4.a Present State of Conservation

In this section, it is demonstrated that the continuous natural erosion of the sea cliff and the landwards lateral extent of the boundary section combined with the legislation, and lack of risks related to climate change or natural disasters result in a very good and improving state of conservation of the nominated Stevns Klint site.

The erosion caused by wave action is the most important factor in the conservation of the nominated property as it secures fresh outcrops, hinders overgrowth, and erases traces of human activities. The ongoing erosion secures the high quality exposures and forms the major means of protection of the boundary section. Erosion causes the cliff profile to move further inland, where the boundary section is of equally high quality.

Mapping has shown that the boundary layers extend many kilometres landwards beneath the present day landscape. The strata are slowly dipping towards the west but exposures will potentially be found above sea-level at least 5 km behind the present day cliff. Based on average present-day and historic erosion rates of 15 cm pr. year (Appendix 5), the boundary layers will be exposed in very high quality sections similar to present day for a minimum of 20,000 years followed by another estimated 10,000 years of gradually decreasing quality.

The hard Danian limestone forming the upper part of the cliff combined with ongoing wave erosion has resulted in the formation of a steep coastal cliff with a roughness and inaccessibility that largely make parts of the cliff unattractive to a range of human activities and developments. Thus, the unique geology defining the nominated Stevns Klint site not only constitutes potential outstanding universal value but also bears its own means of protection.

The dormant remains of quarrying from the area's industrial and preindustrial history (see Section 2.b) persist in a few locations within the nominated area. Current legislation restricts future development of the

activity as well as future activities in neighbouring areas and in the buffer zone (Section 5).

The two abandoned quarries included in the nominated area have now been transformed into protected nature and recreational areas, respectively, supporting accessibility for visitors to the nominated property. These areas are partly included in the nominated area, and are in a good state of conservation although the Holtug Kridtbrud will soon need to be pruned.

Traces of historical quarrying of limestone for building blocks directly from the cliff face presently cover part of the nominated section (see Section 2.b). The traces from this activity are not in conflict with visitors' view of the cliff or with scientific studies of the boundary section. All traces of quarrying are slowly disappearing due to natural wave erosion (Fig. 54).

The part of the nominated area that is comprised by the 1.6 km of tunnels of the Cold War fortress Stevnsfort is in a very good state of conservation with all flint bands clearly visible and the limestone generally free of algae and fungus. Local overgrowth is found in the 400 m long tunnel connecting the southern and northern sector of the fortress. The overgrowth does not affect the visibility of the flint bands.

Fossils collected at Stevns Klint are housed in international, national and regional museums. As the exposures of Stevns Klint have not altered significantly since the first documented studies in 1759, all existing fossil collections are representative of the present day outcrop. Large collections are found at the Natural History Museum of Denmark, which cooperates closely with the local state-subsidised geological museum, Østsjællands Museum. Today, the museum houses exhibitions, facilities for collection management and for visiting scientists as well as educational and visitor programmes. These activities are in the process of expansion and form part of the conservation effort.

NOMINATION OF STEVNS KLINT

It is concluded that the proposed Stevns Klint site is in a very good and improving state of conservation and that good quality exposures are secured for thousands of years to come.

4.b Factors Affecting the Property

The nominated area comprises 15 km of steep cliff and beach, a tunnel system, a minor seafloor area and abandoned limestone quarries. At present, there are no significant threats to the proposed outstanding value of the nominated property. The risks of natural disasters and environmental pressures are low. Quarrying activity in the nominated area has stopped and legislation ensures that no further production will be introduced. The major concern now regards visitor pressures, including fossil and sample collection (Section 4.b (iv)).

4.b (i) Development Pressures

The nominated property comprises an area of actively eroding coastline that is largely inappropriate for development. The cliff, beach and part of the nominated property comprising abandoned quarries and tunnels of the Cold War fortress are all legally protected under multiple conservation designations and their restrictive planning policies (see Section 5.b).

Adjacent to the nominated area and the buffer zone the active quarry Sigerslev Kridtbrud is strictly controlled by legislation, preventing conflict with the nominated area. The quarry Sigerslev Kridtbrud represents the only industrial site close to the cliff. The production is strictly regulated and monitored, and the risk of pollution from this industry is low.

The area landwards of the nominated area is an agricultural landscape. The agriculture constitutes no threat to the nominated property. However, to improve the



Grassland care by volunteers.

state of flora and fauna along the geological site, parts of the area along the cliff are now being transformed into areas of dry grassland with no addition of artificial fertilisers.

Housing is generally sparse and located far from the cliff, and planning regulations prevent the establishment of new housing. The retreat of the cliff due to erosion will slowly bring some houses closer to the cliff and eventually in danger of falling into the sea. This process continues unhindered and legislation prevents the establishment of breakwaters limiting wave erosion.

Breakwaters have been established at Højerup in front of the Middle Age church, which lost its choir in a rock fall in 1928, and in front of the recreational area of the abandoned quarry Boesdal Kalkbrud. The breakwater structures protecting the Middle Age church will be maintained as they form part of the local history and increase accessibility to the property.

4.b (ii) Environmental Pressures

Environmental pressures on the Stevns Klint areas are expected to be mainly from climatic change causing sea-level rise. With increasing sealevels on a metre-scale as predicted for the next hundred years the boundary layers of the nominated property will still be mainly above sea-level and accessibility will not be limited. Today, beaches are present along one third of the cliff whereas the remaining part the cliff ends directly in the sea. Distribution of beaches along the cliff is primarily a result of coastal processes and most beaches will probably adjust to the slowly rising sea-level.

Higher storm frequencies may result from climate changes and will lead to an increase in erosion. Similarly, an expected increase in rainstorms may cause increased rockfall forming natural coastal protection. As there is a sufficient area containing the boundary layer behind the cliff for at least 5 km, increased rates of erosion will not affect the conservation of the property for at least 20,000 years.

The tunnels of the Cold War fortress may, however, be affected from rising sea-levels. The management plan for the Cold War Museum Stevnsfort includes securing the present entrance openings to the fortress from the sea by sealing them.

If left untouched, exposures in the abandoned quarry Holtug Kridtbrud will eventually suffer from overgrowth. However, a protection scheme is under preparation as part of the Natura-2000 protection to protect the rare habitat. This protection will also improve the state of the geological exposures.

4.b (iii) Natural Disasters and Risk Preparedness

Natural disasters are of no threat to the nominated property. The nominated property lies in an area where the risk of natural disasters is low on a global scale. Tsunamis, floods, wildfires and hurricanes are non-existing or extremely rare in the area, and even if they should occur they would form no threat to the proposed outstanding universal value.

A historical storm was recorded in 1872 with winds of an estimated 32 m/sec. and a sealevel three metres above the normal level. A storm of this magnitude is



Beach in front of cliff.

considered to have no negative conservational effect on the proposed outstanding value of the cliff.

Earthquakes occur in the area but are generally below three on the Richter scale as Denmark is located on the stable European craton with a very low intensity of seismic events. The strongest earthquake recorded in Denmark occurred in 2010 and measured 4.7 on the Richter scale. The earthquake had no registered effect on the cliff or the tunnels of the Cold War fortress.



NOMINATION OF STEVNS KLINT

The tunnels are periodically controlled by a trained geologist for major rockfalls from the walls or ceiling of the tunnels.

It is concluded that natural disasters are of little or no threat to the cliff with the possible exception of the tunnels of the Cold War fortress.

The risk preparedness for the area reflects the low risk for the nominated property and focuses on visitors. The risk of rockfall along the cliff has been analysed

4.b (iv) Visitor/Tourism Pressures

With the low risks of natural disaster, environmental pressure and development severely restricted by topography and legislation, the most significant factor that has potential to adversely affect the value of the nominated property is visitor pressure, including fossil and sample collection.

Although the cliff Stevns Klint has been a national tourist attraction for more than a century, the number of tourists is limited and there has only been little de-

velopment in the local tourism industry. In 2008, the Cold War fortress Stevnsfort was transformed into a successful museum, and together with the nomination of Stevns Klint for the tentative list for World Heritage, this has produced an optimism and significant local interest in developing tourism in the area. Recent developments have generally been well received by the local community who takes pride in the local properties and attractions as well as increased economic optimism and development of the area.



Blocks from rock fall, November 2011.

(Appendix 5), and the analysis provides the basis for regulating access and placing of signs warning visitors about any risks. The local rescue team executes training practices along the cliff and subsurface tunnels and has special equipment for rescue from land and sea. The members of the first responder teams are located five kilometres from the nominated site. All public access to the tunnels is conducted by professional guides trained in rescue operations. A specific emergency plan for the rescue of visitors in the tunnels has been developed in cooperation with the local rescue authority, Stevns Brandvæsen.

In the light of the new interest, Stevns Municipality, the local official tourism agency, and the local geological museum have increased their cooperation, aiming at securing sustainable tourism that is essential to the successful management of Stevns Klint as a geological site. One of the results of this cooperation is the Tourist Policy Report by Stevns Municipality (Section 5.d). The report documents that the area is able to sustain the present-day level of visitors with little adverse impact on the nominated property, the surrounding nature or the local community. At present, there are only few visible signs of tourism pressure on the nominated



property and surrounding areas. The Tourist Policy Report points out that the capacity for sustainable tourism is high, with the exception of the parking area at Højerup.

Most visitors to Stevns Klint arrive at the classical Stevns Klint site at Højerup and enjoy the dramatic view of the church on the edge of the cliff or approach the cliff from the idyllic fishing village Rødvig just south of the nominated area. Both areas have been developed to sustain tourism, although parking facilities only just meet the present need at Højerup. In recent years, a number of additional attractions have been developed and presented to the visitors as series of attractions along the cliff. The increased numbers of visitor sites serve to ensure a sustainable distribution of tourists along the cliff, thereby increasing the total carrying capacity of the nominated area.

Sustainable tourism is a key issue in the management plan produced by Stevns Municipality (Appendix 4). The management plan has been produced through a process of communication between the local municipality and the local tourism agency, the museum, local NGOs, and landowners and neighbours of the property (Section 5.e). Sustainable tourism in the management plan includes the sustainability of the natural properties as well as the socio-cultural and financial sustainability, and the plan includes definition of challenges, targets and activities.

Fossil collection is essential to secure exposed fossils and thus forms part of the conservation. Unless the fossils are collected from the cliff and fallen blocks on the beach, the constant erosion will cause the fossils to be washed away by the sea.

Therefore, it is planned to optimise the collection of fossils through an active collection programme (Section 5.c). Today, fossil collection is performed as part of scientific studies, by skilled amateurs, and by tourists. Particularly valuable fossils are

protected under the Museum Act, which protects geological objects and fossils of unique scientific or exhibition value. Such objects are called Danekræ (Fossil Trove) and belong to the State. The Museum Act's provision on fossil trove is included in Appendix 2.

With the increased interest in Stevns Klint as a geological site, there is reason to expect increasing interest in fossils and the boundary clay from unskilled as well as skilled and professional collectors. The impact of collection will be persistently monitored and evaluated as part of the management plan (Section 6.a and Appendix 4) in order to protect the nominated value and to secure communication between international scientists and the local geological museum with the purpose of tying new scientific results to the presentation of the area. Visitors are informed and educated about the fossil collecting legislation and policy in the site literature, on interpretive signs and through verbal communication. A code of conduct for scientific and amateur sampling is to be in place for the summer season 2012 produced by Stevns Municipality in cooperation with the local geological museum, Østsjælland Museum, and local stakeholders.

4.b (v) Number of Inhabitants Within the Property and the Buffer Zone

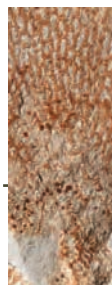
The nominated area comprises a rugged coastal cliff, beaches, tunnels and abandoned quarries unsuitable for human habitation. Hence, there are no inhabitants in the area. The buffer zone include a marine area with no inhabitants and a wide landwards area dominated by an agricultural landscape with scattered private houses and small farms (Table 7).

Area of nominated property	50 hectares
(Length of coastal cliff: 1.5 km)	
Estimated number of inhabitants within the nominated area	0 inhabitants
Area of buffer zone:	
Sea, up to 300 m seaward from shoreline	3665 hectares
Land: 300 m landward from cliff break	471 hectares
Estimated number of inhabitants within the buffer zone	165 inhabitants

Table 7. Area and number of inhabitants of the nominated site and buffer zone.



5. Protection and Management of the Property



The nominated area is protected and conserved by an established framework of national legislation and protective designations as well as by local planning policies. These arrangements are reinforced through a series of national legislation and local planning documents, which are described within the appendices. The Management Plan for the nominated World Heritage Site, produced and approved by the Municipality of Stevns (Appendix 4) sets out agreed objectives for the nominated site. This Management Plan has been the subject of local public consultations.

5.a Ownership

In general, there are two forms of ownership in the nominated area: Public (governmental and municipal) and private (associations, companies and individuals) (Table 8). The actual cliff is primarily private property with the local estate Gjorslev Gods as the largest owner. The abandoned quarry Holtug Kridtbrud belongs to the State, while the abandoned quarry Boesdal Kalkbrud is the property of Stevns Municipality, who also owns the passages in the Cold War Fortress Stevnsfort and the cliff off part of Stevnsfort. The marine area belongs to the State.

National legislation stipulates that the public has right of access to the beach (Section 5.b).

The attractions along Stevns Klint, which serve as access routes to the cliff, are all owned by public authorities or private associations and private foundations,

Locality	Owner
Stevns Klint	Private, Gjorslev (95%) Private, other (3%) Stevns Municipality (1%) State (1%)
Geological profile in Boesdal Kridtbrud	Stevns Municipality
Tunnels in Cold War fortress Stevnsfort	Stevns Municipality
Holtug Kridtbrud	State
Seafloor	State

Table 8. Ownership of nominated property

whose purpose it is to present and manage the natural and culture-historical heritage of the areas (Table 9).

5.b Protective Designation

The nominated area and the buffer zone are covered by a number of acts, which each sets out the framework for human activity.

The nominated area and the buffer zone are protected by the **Planning Act** (Consolidated Act no. 937 of 2009, Appendix 2). The Act is to ensure that the overall planning combines social interests in the use of the area and contributes to protecting the nature and environment so that social development can take place on a sustainable basis with respect for human living conditions and for the preservation of fauna and flora.

The Planning Act defines, among other things, a number of restrictions on partitioning, newbuild and changes of existing built-up areas in the coastal zone,

Attraction/locality	Owner	Caretaker
Boesdal Kridtbrud	Stevns Municipality	The association Foreningen Boesdal
Stevnsfort	Stevns Municipality	Østsjælland Museum
Højeruplund	The association Selskabet Højeruplund	The association Selskabet Højeruplund
	Østsjælland Museum	Østsjælland Museum
Stevns Fyr	State	Stevns Municipality
	Stevns Municipality	Stevns Municipality
Mandehoved/Flagbanken	Stevns Municipality	Østsjælland Museum
Holtug Kridtbrud	State	Østsjælland Museum

Table 9. Ownership of areas with public access to the nominated site.

NOMINATION OF STEVNS KLINT

and ensures that coastal areas are kept clear of buildings and facilities that are not dependent on being close to the coast (Planning Act Section 5a.) (Appendix 2). The extent of the coastal zone is shown in the map appendix to the act. A detail showing the extent around the nominated area is included in Appendix 2.

The **Planning Act** (Consolidated Act no. 937 of 2009) stipulates that municipal planning must secure and preserve large, unbroken landscapes, and that municipal plans must contain guidelines on how to secure

been designated a GeoSite and is therefore included in a network of particularly significant European geological areas of scientific importance. The organisation ProGeo is in charge of organising the description of GeoSites within Europe on behalf of IUGS (International Union of Geological Societies). In Denmark, this has been effected via Nationalkomiteen for Geologi (the National Committee of Geology). Stevns Klint represents the first two of twelve themes, i.e. the Cretaceous–Tertiary boundary (GS 1-1) and the Danian strata and boundary to the overlying Selandian

(GS 2-1), where Stevns Klint demonstrates the strata and lower boundary to the Maastriichtian. Thus, Stevns Klint must be characterised as an areas of special geological value in accordance with the Planning Act.

The cliff is protected under the Danish **Act on the Protection of Nature** (Consolidated Act no. 933 of 2009, Appendix 2), which stipulates that no changes must be made to the condition of beaches or other areas that are located between the beach and the beach protection line. Furthermore, no fences must be established,

nor is it permitted to place caravans or the like in such areas. The beach protection line in the nominated area is established by the State (the Minister for the Environment) and generally extends to 300 m from the coastline. The beach protection line is registered in the land register and the land charges register for each affected title number. The Act on the Protection of Nature's provision on the beach protection line and a map showing the beach protection line around the nominated area are included in Appendix 2.

A flock of swans over the 1928 rock fall.

general geological preservation values. The provisions of the Planning Act on landscape and geological preservation values in municipal planning are included in Appendix 2 (Planning Act Section 11a).

It is an objective of the **Planning Act** that areas of special geological value are secured (Planning Act Section 11a, item 16). Stevns Klint has been designated a 'Site of National Geological Interest' by the Danish government in collaboration with GEUS (the Geological Survey of Denmark and Greenland). Stevns Klint has also



Photo: Jakob Laurrup, GEUS



Coastal protection is governed by the **Act on Coastal Protection** (Consolidated Act no. 267 of 2009).

Weighty arguments are needed if coastal protection facilities are to be established along the coast off Stevns Klint, which is currently generally untouched by such facilities as a whole. The more valuable a coastline is considered to be in terms of coastal dynamics, geology, landscape and biology, the greater the requirements on the justification for establishing such a facility.

The extraction of raw materials is governed by the **Raw Materials Act** (Consolidated Act no. 950 of 2009), the purpose of which is to ensure that the exploitation of raw material deposits on land and at sea is carried out as part of a sustainable development. Along Stevns Klint, there are a number of historical rights, the so-called registered rights, which expire in 2028. However, it is expected that an application for permission to exploit registered rights will be rejected, as the reclamation is incompatible with the position within the beach and beach protection line and the designation as a Site of National Geological Interest. It is therefore considered completely unlikely that permission will be granted for reclamation within the 300 m protection line.

Particularly valuable fossils are protected under the **Museum Act**, (Consolidated Act no. 1505 of 2006, Appendix 2), which protects geological objects and fossils of unique scientific or exhibition value. Such objects are called *Danekræ* (Fossil Trove) and they belong to the State. The Museum Act's provision on fossil trove (Section 31) is included in Appendix 2.

In relation to public access to Stevns Klint, it is particularly worth noticing that the **Act on the Protection of Nature**, Section 22 (Consolidated Act no. 933 of 2009) stipulates that the beach must be kept open for passage on foot and for brief occupancy (Appendix 2).

Further to the legislation that protects the nominated value, fauna and flora are also protected. Fauna and flora along Stevns Klint are protected under the **Act on the Protection of Nature**, which protects a num-

ber of rare or endangered animal species against deliberate interference that may have a harmful effect on the species or the population.

The abandoned quarry Holtug Kridtbrud has been designated a Natura 2000 area (international nature protection area 182 and habitat area H183), and it is therefore covered by the **EU Habitat Directive** and the **Act on Environmental Objectives** (Consolidated Act no. 932 of 2009). Additionally, birds are covered by the **EU Birds Directive**.

The sea area that constitutes the buffer zone towards the sea has been designated a Natura 2000 area (international nature protection area 206 and habitat area H206), and it is therefore covered by the EU Habitat Directive and the **Act on Environmental Objectives** (Consolidated Act no. 932 of 2009). The area is also governed by the **Act on Fisheries** (Consolidated Act no. 978 of 2008), whose objective it is to secure both protection of and support for living resources in seawater and protection of other fauna and flora. The Act on Fisheries prohibits otter trawling and pelagic trawling in the area off Stevns Klint.

5.c Means of Implementing Protective Measures

Stevns Municipality is the local authority responsible for implementing legislation. The **Planning Act** (Consolidated Act no. 937 of 2009) is the basic planning tool for Stevns Municipality. The Act ensures that a general structure be established along with guidelines for the land use. In this general structure, Stevns Municipality has designated Stevns Klint as a particularly valuable nature area (Stevns Municipal Plan 2009, 16,1). The fundamental starting point is that no buildings may be erected, and no activities or alterations may take place without extensive consideration for the geology and nature and the landscape values. In the Municipal Plan, Stevns Municipality has established an objective about ensuring that due consideration is given to the geological interests and that these are to be preserved for the use of research and dissemination.



Photo: Peter Worm-Moors



NOMINATION OF STEVNS KLINT



Figure 55. Functional buffer zones shown in relation to nominated area. The functional buffer zones are defined around visitor sites to highlight the importance of these areas in the management of a range of visitor functions and activities.

It is also the objective of the Municipality to ensure that work is carried out to make the geological profiles accessible to the public (Stevns Municipal Plan 2009, 16,3).

A buffer zone is defined with the primary purpose of achieving protection and management of the nominated property (Fig. 1, Appendix 1, 4). The role of the buffer zone is expanded to include the protection of the wider natural system formed in connection to the property and additionally to relate to the management of visitor pressure to the nominated property and the associated natural and cultural elements.

The buffer zone for the nominated site is defined with the primary purpose of achieving protection and man-

agement of the nominated property. The buffer zone is outlined following boundaries of existing areas of legal protection. Landwards, the buffer zone follows a national 300 m coastal protection zone and seawards, it generally follows the boundary of an area included in the European Natura 2000 network of protected areas (Fig. 1, Appendix 1). The buffer zone covers the area important in protecting the view in and out of the proposed area, including views from the top of the cliff, from the shore or from the sea. The boundaries of the buffer zone also ensure inclusion of areas important for the wildlife related to the cliff and a marine stone reef and the flora and fauna related to the cliff and dry grassland.

5. PROTECTION AND MANAGEMENT

The buffer zone includes a range of cultural heritage sites related to the nominated property, including remnants of limestone production facilities, buildings of stones from the cliff, and the Cold War fortress dug out into the rock. Several of the cultural sites are protected, including the old church on the edge of the cliff and the two lighthouses. The Cold War fortress is in the process of gaining legal protection.

Functional buffer zones are defined around visitor sites to highlight the importance of these areas in the management of a range of visitor functions and activities (Fig. 55). The functional buffer zones are designated with substantial stakeholder engagement to ensure the area an important role for the local community, supporting sustainable use in consistency with the protection of the nominated area as well as the natural and cultural properties of the buffer zone.

Stevns Municipality works actively to improve the nature experience and the accessibility to areas along the cliff through the acquisition of land. With this in mind, over the past 20 years, Stevns Municipality has acquired the area at the Cold War Fortress Stevnsfort, the abandoned quarry Boesdal Kalkbrud, the abandoned Cold War facility at Mandehoved, and areas around the lighthouses Stevns Fyr. Today, these areas are looked after through nature preservation in order to enhance the nature experience at Stevns Klint. Preservation plans have been elaborated for Boesdal, Stevnsfort and Stevns Fyr (Section 5.d).

Nature preservation along Stevns Klint is carried out in collaboration between Stevns Municipality, the Danish Nature Agency, the local branch of the NGO Danish Society of Nature Conservation, the local museum and private plot owners. Stevns Municipality has also prepared an action plan for Sand Lizard (*Lacerta agilis*) and is collaborating with the Danish Nature Agency, the Danish Ornithology Association and the Royal Danish Aero Club on the protection of Peregrine Falcon at Stevns Klint.



Photo: Jakob Laurrup

Figure 56. The public footpath running along the length of the cliff.

The Municipality has improved access to Stevns Klint through the so-called *Trampesti* footpath, which was opened in 2004 (Fig. 56). The footpath makes it possible to walk along the entire cliff, at the top or on the narrow stretch of beach at the foot of the cliff. The path is based on voluntary agreements between the Municipality and 52 plot owners. Nature preservation along the cliff is agreed as part of the formalised dialogue about this agreement.

The **Planning Act** makes it possible to outline detailed plans for land use in a limited area. As for the buffer zone, such local plans have been drawn up for Boesdal Kalkbrud, the Cold War Museum Stevnsfort, and Stevns Fyr. A local plan for Højerup is planned for 2012.

Research on Stevns Klint is carried out by researchers from all over the world. The local state-recognised museum, Østsjællands Museum, is under legal obligation to collect, register, preserve, research and disseminate information on Stevns Klint in accordance with the

NOMINATION OF STEVNS KLINT

Museum Act. The collaboration on regulations of collection is formalised in a separate contract between Stevns Municipality, Østsjælland's Museum, and the main private plot owner Gjorslev Gods. The Museum is funded by Stevns Municipality and the Danish State. The Museum was given its geological responsibility in 2002 and now works in close collaboration with the University of Copenhagen and the Natural History Museum of Denmark on handling the task. Work plans for the museum are forwarded to Stevns Municipality and the Heritage Agency of Denmark.

5.d Existing Plans Related to Municipality and Region in which the Proposed Property is Located

Municipal Plan for Stevns Municipality

The Municipal Plan is a statutory framework plan for land use in the municipality. The Management Plan continually refers to legislation, directives, regulations etc.

Stevns Municipal Plan contains guidelines to secure general geological preservation values, including the location of areas of particular geological value in relation to the current Planning Act. In comments to the legislation, it has been specified that the quality of Areas of National Geological Interest is not to be reduced by obscuring or destructing through digging, by buildings or technical facilities, forest planting or similar. In terms of protection, Geo-Sites are ranked alongside Areas of National Geological Interest.

In Stevns Municipal Plan, Stevns Klint is designated a 'particularly valuable nature area'. This implies that no alterations must take place in the area without extensive consideration for the geology, nature, and landscape values.

District Plans

District plans are prepared by the municipalities for small areas. District plans are detailed and binding on plot owners. In relation to the nominated area, district plans have been prepared for the localities Boesdal Kalkbrud and the Cold War Museum Stevnsfort. District plans for the area include guidelines for the use of



The main entrance of Gjorslev Gods.

Communication about Stevns Klint is handled by Østsjælland's Museum from a number of localities along the cliff (Section 5.i).

5. PROTECTION AND MANAGEMENT

the areas and concrete preservation plans with a view to nature protection. In relation to the buffer zone, a district plan has been prepared for Stevns Fyr, and a district plan for Højerup is planned for 2012. Preservation plans have been elaborated as part of district plans for the areas by Stevnstoft, Stevns Fyr and Boesdal. The preservation plans are binding and describe detailed plans for the nature preservation of the areas.

Tourist Policy Report

A Tourist Policy Report for Stevns has just been completed. The Tourist Policy Report is included as an appendix to the Municipal Plan. The report maps current tourism and its potentials, and objectives are set out for future development. The focal point of the Report is the sustainable development of tourism.

Road Safety Plan and Traffic Plan

Stevns Municipality has prepared a Road Safety Plan with the objective of targeting work of the Municipality to increase road safety, and create a safe setting for people to move around the municipality. Stevns Municipality has plan to draw up a Traffic Plan to ensure appropriate traffic management and development of infrastructure in the municipality.

Østsjælland's Museum Work Plan

The Work Plan of Østsjælland's Museum constitutes the framework for the activities of the museum and is forwarded to the Heritage Agency of Denmark and Stevns Municipality. The Work Plan defines that the Museum works within the target areas of geology and cultural history with the objective of preserving and

communicating natural and cultural heritage. The Work Plan defines a number of target areas including the geological and cultural history of Stevns Klint.

Nature Policy

Stevns Municipality is in the process of preparing a Nature Policy.

Plans for Endangered nature

Preservation plans for the Natura 2000 areas Holtug Kridtbrud and Stevns Reef are being prepared by the



Autumn at the graveyard of the abandoned Højerup Church.

government and expected to be completed in the autumn of 2012. Stevns Municipality has prepared an action plan for Sand Lizards.

5.e Property Management Plan

The Stevns Klint Management Plan has been prepared by Stevns Municipality in close collaboration with Østsjælland's Museum. The Management Plan has been drawn up with a high degree of inclusion of local residents, interest organisations, advisory organs, and

NOMINATION OF STEVNS KLINT

other stakeholders through a number of theme meetings for plot owners, and for the general public. The Management Plan has been presented to the public and public meetings have been held about the Plan with all relevant stakeholders.

The Management Plan is a general management tool to be used by all who are involved in the work to protect Stevns Klint in a sustainable manner. Thus, the Management Plan sets out visions, objectives and targets for the work to protect, present, and develop

tainable foundation that takes its starting point in the preservation of the core values of Stevns Klint.

The Management Plan is enclosed with the nomination material as a separate volume (Appendix 4).

The overall objectives of the Management Plan are:

- To improve the possibilities of public and formal education and research about Stevns Klint.
- To ensure protection, scientific studies and education of the values that form the basis for the nomination of the area to be inscribed on the World Heritage List, i.e. the geological layers at Stevns Klint.
- To describe the tasks of different players in relation to managing, protecting, preserving, developing and presenting Stevns Klint.
- To explain the significance of Stevns Klint to all residents, users and visitors in the area with a view to increase interest and respect for the area.
- To present visions, objectives and targets for Stevns

Klint and the surrounding area.

- To account for challenges and describe measures that has already been effected or will be initiated to protect integrity of the area.
- To provide visitors with quality experiences by anchoring and developing tourism on a sustainable foundation.
- To create increased coordination and collaboration between the involved stakeholders.



Public meeting with stakeholders.

Stevns Klint, and the Plan indicates a number of measures in various areas that are of significance to Stevns Klint, including the buffer zone.

The Management Plan stresses the importance of considering the value of Stevns Klint as part of a whole, so that apart from the geological values, focus is also on the inclusion of the living nature, cultural history and overall experience of the cliff. In this way, the Management Plan aims to ensure development based on a sus-



The Management Plan describes a number of recommendations and a timeframe for their execution. A number of the recommendations can be carried out within the existing operational framework. Collaboration between Stevns Municipality and Østsjælland Museum aims to procure funding for other recommendations.

5.f Sources and Levels of Finance

A sustainable development of Stevns Klint based on the preservation of the values involves a large number of tasks related to preservation and protection of the geological core value but also nature preservation, research, education, development of tourism and infrastructure as described in the Management Plan (Appendix 4). A large number of these tasks are currently being handled by various organisations, which makes it difficult to determine the level of finance. Stevns Municipality has decided to contribute 3 million Danish kroner annually for five years as a supplement to the current handling of tasks.

The actual nominated value is primarily maintained by the ongoing erosion and does not require preservation as such. However, preservation of the nominated area in the abandoned quarry Holtug Kridtbrud is needed. This preservation is funded by the Danish Nature Agency.

The living nature on and along the cliff requires care in order to preserve the characteristic dry grasslands along the cliff, which increase the nature value and provides a view of the cliff from the cliff edge. Nature preservation along the cliff is currently funded primarily by Stevns Municipality and the Danish Nature Agency, Østsjælland Museum, the private association that owns the area at Højerup, and to a lesser degree by private plot owners. In 2010, an experimental scheme was launched, which involves voluntary organisations in the nature preservation work. The conclusion that is drawn is that the finances are currently sufficient to handle the core value and the special nature.

Increased knowledge of the core value is considered part of the preservation. Research is carried out by researchers from all over of the world. Locally, research is carried out at Østsjælland Museum, which also works on anchoring research in the local area through formal and informal education (see Section 6).

Education about the cliff is handled by Østsjælland Museum, which ensures operations through funding from the Danish State, the local municipalities and earnings from entrance fees from visitors. Establishment costs in relation to large projects such as digital communication along the entire cliff, and expanding school service offers are largely funded by large Danish foundations. The plan is to use the same model in connection with funding of a new geological exhibition and visitor centre.

The expansion and maintenance of infrastructure with access to the area is included as part of ordinary operating budget of Stevns Municipality. The general infrastructure is adequate. Funding for new establishment of an expanded visitor centre, new paths, stairs etc. will be sought through foundations and supplemented by public funding from the State and Stevns Municipality.

It is concluded that funding is funding to secure the World Heritage value and to create a complete experience for visitors.

5.g Sources of Expertise and Training in Conservation and Management Techniques

Geological expertise about the conservation of the cliff and the fossils is based locally at Østsjælland Museum and with the permanent partners, the Natural History Museum of Denmark, the University of Copenhagen, and the Geological Survey of Denmark and Greenland (GEUS). This means that there is access to the foremost expertise in the field. The Museum has qualified experts at its disposal.

NOMINATION OF STEVNS KLINT

Attractions with visitor facilities	Facilities
Rødvig – an idyllic fishing town, view of the cliff	Parking. Public toilets, including toilets for disabled people. Various dining and shopping possibilities. Hotels. Bed and Breakfast. Tourist information. Serviced by public transport (train and busses). Guided tours during the summer.
Boesdal – an abandoned quarry with historical buildings	Parking. Public toilets. Access for wheelchairs. Shelters. Picnic facilities.
Cold War Museum Stevnsfort	Parking. Professional museum including toilets, picnic facilities, souvenir shop. Guided tours.
Højerup – the classic Stevns Klint locality with the church on the edge of the cliff, including a professional museum with permanent exhibitions	Parking. Public toilets. Picnic facilities. Bed and Breakfast. Eatery/café. The museum houses visitor facilities, including toilets, picnic facilities, souvenir shop and access for wheelchairs.
Stevns Fyr – two protected lighthouses	Parking. Public toilets. Access for wheelchairs. Picnic facilities. Exhibitions. Access to lighthouses. The area was recently opened to the public and is under development.
Mandehoved/Flagbanken – vantage point and school service	Parking. Public toilets. Access for wheelchairs. Picnic facilities. Exhibitions. Bird watch tower. Centre for school presentations, including sleeping facilities for groups. Primitive shelters.
Holtug Kridtbrud – an abandoned quarry	Parking. Public toilets. Picnic facilities.

Table 10. Visitor facilities.

Expertise in conservation of the geology and nature of the area rests with Stevns Municipality and the Danish Nature Agency, who have great experience and competence in the conservation of dry grasslands. The local branch of the NGO the Danish Society of Nature Conservation has competences in the conservation of living nature and collaborates with Stevns Municipality and Østsjælland Museum.

Stevns Municipality handles managerial tasks. The management of the local natural and cultural heritage is carried out with guidance from the Heritage Agency of Denmark who also handle supervision of the protected buildings.

It is concluded that the combined expertise in conservation of the geological value and management of the area is very good.

5.h Visitor Facilities and Statistics

The 15 km of cliff can be experienced by boat from the sea, by foot along the beach, or from a path that runs along the top of the cliff. Inland, the cliff can be approached from the road that runs in parallel to the cliff (Fig. 1).

A series of locations along the cliff includes visitor facilities. The locations are generally staffed and comprise areas of particular natural or cultural interest (Table 10).

5. PROTECTION AND MANAGEMENT

Visitor statistics for the Stevns Klint area are difficult to track because of the open access. The Cold War Museum that opened in 2008 counts about 40,000 visitors annually, the Stevns Museum at Højerup has about 5,000 visitors, the Stevns Nature Centre has about 3,000 on guided tours, and an estimate of 60,000 visit the main Stevns Klint site at Højerup.

5.i Policies and Programmes Related to the Presentation and Promotion of the Property

Dissemination and education of information about geology at Stevns Klint is handled by Østsjælland Museum, who also communicates about the nature and cultural history of the area. The Museum handles dissemination and education based on a permanent staff of scientific and communication experts. The vision is to make people wonder about and consider new perspectives on life and history through research-based stories told vividly and effectively, taking their starting point in authentic localities. The dissemination and education is described in the Museum's Work Plan (Section 5.c and 5.d).

The existing communication at Stevns Klint by Østsjælland Museum comprises:

- Stevns Museum (approx. 5,000 visitors per year)
Traditional cultural history exhibition and new special exhibition about Stevns Klint as a candidate for UNESCO's World Heritage List
- Flagbanken: Small geology exhibition (estimated no. of visitors 20,000)

- Cold War Museum Stevnsfort (approx. 40,000 visitors per year)
A room in the fortress houses a geological exhibition.
- Public walks along the cliff (nature, geology and cultural history)
- Stevns Fyrcenter – small exhibition
In collaboration with Stevns Municipality, the Danish Nature Agency and a local NGO
- School service about geology and nature based at Stevns Naturcenter.
- General information activities about Stevns Klint.



The small geological exhibition at Flagbanken is always open to the public free of charge.

Østsjælland Museum continually contributes to public knowledge about the cliff and its history, e.g. through the production of books and pamphlets, lecture activities, articles in newspapers and magazines, and participation in radio and TV shows.

Østsjælland Museum continues to expand the dissemination by incorporating more communication interfaces, extending the school service, and creating a new geological exhibition.

NOMINATION OF STEVNS KLINT

A complete communication interface is presented to visitors at Stevns Klint via the digital communication project Stevns Klint+. The presentation uses web, smartphones and digital info stands as well as traditional signage. The project is funded by a grant from the foundation Nordea-fonden and is carried out in collaboration with Stevns Municipality.

The Museum's existing school service is being expanded through the establishment of special offers aimed at lower and upper secondary schools. The project covers

complete experience. The establishment of the visitor centre is part of the intentions contained in the Management Plan for Stevns Klint (Appendix 4).

5.j Staffing Levels

Østsjælland's Museum handles research and dissemination in Stevns Municipality and the neighbouring Faxe Municipality. The staff includes two qualified research geologists and two historians, who all have expert knowledge, conduct research, and participate in

the dissemination about the geology, nature and cultural history. The Museum has at its disposal two professional communicators, who have specialised in the Cold War and the nature of Stevns Klint, respectively. Both communicators have authorised communication qualifications, and the Museum trains its own corps of guides. The Museum now has some 25 part-time guides and expects to see an increase in this number.

Additionally, the Museum has administrative personnel as well as technical personnel who handle maintenance

of exhibitions as well as areas at Flagbanken, Højerup, Holtug Kridtbrud and Stevnsfort. The society Selskabet Højeruplund has a half-time employee who tends the area at Højerup. Volunteers take part in the preservation of Stevnsfort and the area at Boesdal. Stevns Municipality contributes by having professional companies tend the path along the cliff. In all, about five people work full-time with nature preservation and maintenance of buildings in use for dissemination purposes.



Tours along the cliff are popular for visitors of all ages.

geology, nature and cultural history with a particular focus on the Cold War. The project is funded by a grant from the foundation Augustinus Fonden.

Østsjælland's Museum is planning to extend the existing exhibition at Højerup. The objective is to create a visitor centre, which will form the natural entrance to Stevns Klint and provide visitors with the basis for a





6. Monitoring



6.a Key Indicators for Measuring State of Conservation

Geology

The nominated area is made up of an active coastal cliff, where wave erosion ensures good conservation of

the locality's core values. Thus, the most significant factor in the conservation of the geological core value is the erosion and the retrogradation of the cliff. Key issues for measuring state of conservation of the geological values are listed in Table 11.

Focus	Indicator	Method	Evaluation	Frequency	Responsibility
Erosion and backstepping of the cliff	Backstepping of cliff	Registration of backstepping and falling parts of the cliff.	Assessment of the effect of backstepping on core values and integrity	Continually	Østsjællandss Museum Stevns Municipality Plot owners
Collecting of geological material – in general	State of geological profile with focus on the boundary clay and traces of tools in the geological layers	The state of the geological profile is registered and mapped – particularly around the visitor sites Boesdal Kalkbrud, Højerup and Holtug Kridtbrud.	Comparison of information from year to year will provide answers as to whether the geological value and the integrity are endangered now or in the longer term.	During the months of May and October	Østsjællandss Museum
Collecting of geological material – research	Research activity in the nominated area	Researchers are encouraged to notify Østsjællandss Museum of their field studies.	Assessment of where and to what extent Stevns Klint can sustain research activity at the given time	Continually	Østsjællandss Museum
Research	Published papers	Retrieval of published papers from peer-reviewed journals	Overview of new research and assessment of how this could possibly be communicated to visitors.	Annually	Østsjællandss Museum
View points	Clear view to Stevns Klint from view points	The view points along Stevns Klint are checked for overgrowth and anything else that might limit or block a clear view	Assessment of whether overgrowth or anything else obstructs the visual experience of Stevns Klint	Annually	Stevns Municipality Østsjællandss Museum
Communication	Satisfaction with information boards, guided tours, visitor centre etc.	Survey among visitors. This will be carried out as part of a survey of visitor experience	Quantitative and qualitative assessment of whether the communication meets the need of present and future visitors	Annually	Stevns Municipality Stevns Tourist Office Østsjællandss Museum

Table 11. Key issues relevant for monitoring the state of conservation of the geological values.



NOMINATION OF STEVNS KLINT

Recently, knowledge on the erosion process has increased based on an erosion analysis (Appendix 5), and at the same time, a better basis has been created for registration of erosion along the cliff. Based on these new data, reporting of large slides will be made possible, which will facilitate greater knowledge of backstepping of the cliff. The existing oblique aerial photographs of the entire cliff taken in 1992 and 2011 will also contribute to the establishment of a database of knowledge about the condition of the cliff.

Collecting of fossils along Stevns Klint is important to the conservation of the fossil record. Stevns Klint has not previously been exposed to fossil collecting to an extent or in a way that has been contrary to the desire

Communication of the geological and nature values of the cliff is considered a significant factor in the conservation. The objective of monitoring the communication is to secure that information about Stevns Klint is sufficient to satisfy the different target groups.

Nature

The nature areas along Stevns Klint are monitored to obtain information that can contribute to the management of nature in future (Table 12). Details are described in the Management Plan (Appendix 4).

Tourism

In order to ensure sustainable tourism, emphasis is placed on assessing the experiences of tourists and

Focus	Indicator	Method	Evaluation	Time Schedule	Responsibility
Flora and fauna	Number of specific animals and plants that thrive on the oligotrophic limestone overhang	Monitoring and registration of specific plants and animals at selected localities along the cliff.	Quantitative measuring to monitor biodiversity in the nature areas. Assessment of whether the preservation plans live up to their objectives	Annually	Stevns Municipality
Wear and waste in nature	Wear on vegetation and waste as a result of human activities in the nature areas and on the footpath along Stevns Klint	Wear and waste in and around the nature areas is registered by means of observations, photos and mapping	Assessment of whether wear constitutes a problem Assessment of waste handling in nature	Annually	Stevns Municipality Østsjællandss Museum The Danish Nature Agency The society Selskabet Højeruplund The association Foreningen Boesdal

Table 12. Key issues for the management of nature areas along Stevns Klint.

for conservation. In order to investigate whether collecting damages the nominated area, the area will continually be checked for amount and extent of possible damage.

The experience of the cliff from the top of the cliff is affected by overgrowing plants at the cliff edge, and this overgrowth will be monitored to form the basis for a preservation programme.

plot owners (Table 13). Details are described in the Management Plan (Appendix 4).

6.b Administrative Arrangements for Monitoring Property

Objectives for conservation and frequency of monitoring are established in the Management Plan for Stevns Klint (Appendix 4). Stevns Municipality is responsible for fulfilling these objectives and for monitoring, and

Focus	Indicator	Method	Evaluation	Time Schedule	Responsibility
Visitor statistics	Overnight stays Number of visitors Distribution	Information is gathered from places offering overnight accommodation and visitors sites	Assessment of the capacity for overnight stays, visits and distribution	Annually	Stevns Tourist Office
Visitor experiences	Visitor assessment of Stevns Klint, the visitors sites, facilities, services, information etc.	Survey among visitors	Quantitative and qualitative assessment of visitor experiences and requirements	Every two years	Stevns Municipality Stevns Tourist Office Østsjællandss Museum
Wear and waste at the visitor sites	Wear and tear of visitors site facilities, including the footpath Path formation at the visitor sites Waste left behind	Wear, path formation and waste in and around the visitor sites are registered by means of observations, photos and mapping.	Assessment of whether wear constitutes a problem Assessment of waste handling at the visitor sites	Annually	Stevns Municipality Østsjællandss Museum Plot owners
Plot owner experience	The effect of tourism as experienced by the plot owner	Plot owner meetings are held	Assessment of plot owner experience in relation to the overall value of the nominated area	Annually	Stevns Municipality

Table 13. Key issues of interest to ensure sustainable tourism.

the task is handled in collaboration with Østsjællandss Museum, Stevns Tourist Office, and other stakeholders in the area. Stevns Municipality has decided to fund a separate organisation with the participation of key stakeholders, to handle this task from 2012. Monitoring data will be available from Stevns Municipality. The Danish Nature Agency is responsible for monitoring of the areas included in the European Natura 2000 network of protected areas.

6.c Results of Previous Reporting Exercises

No systematic reporting has been carried out previously. However, traffic loads are being monitored by Stevns Municipality.



7. Documentation

7.a Photographs, Slides, Image Inventory and Authorization Table and other Audio-visual Materials

Appendix 3.5 Photographs of Stevns Klint

7.b Texts Relating to Protective Designation, Copies of Property Management Plans or Documented Management Systems and Extracts of Other Plans Relevant to the Property

Appendix 1 Maps

Appendix 2 Legislation

Appendix 4 Management Plan

Appendix 5 Erosion Analysis

7.c Form and Date of Most Recent Records or Inventory of Property

Appendix 1 Maps

Appendix 3 Inventory of Property

3.1 Fossils at Stevns Klint

3.2 Geological Profile of Stevns Klint

3.3 Birds at Stevns Klint

3.4 Dry Grassland Flora at Stevns Klint

Appendix 6 Comparative Analysis

7.d Address where Inventory, Records and Archives are Held

Stevns Municipality

Postboks 83

4660 Store Heddinge, Denmark

Østsjælland Museum

Højerup Bygade 38

4660 Store Heddinge, Denmark

7.e Bibliography

This bibliography of scientific publications concerning the Cretaceous-Tertiary boundary section Stevns Klint has been compiled with the aid of GeoRef and Web of Science databases in May 2011. Reference to the locality Stevns Klint is found in more than 400 publications. However, some of these only present references to earlier work by others. In this bibliography only papers presenting original work on the Stevns Klint locality is included.

The bibliography comprises refereed journal papers, book chapters, and textbooks/memoirs. Government/museum reports, theses, conference papers, and abstracts are not included.

A total of 230 documents published between 1759 and the present are arranged alphabetically as follows:

1. Abildgaard, S. (1759). *Beskrivelse over Stevns Klint og dens naturlige Mærkværdigheder*. Copenhagen.
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NOMINATION OF STEVNS KLINT

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9. Signature on Behalf of the State Party



Date

Uffe Elbæk
Minister of Culture

Citation by Section

Section 2

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Section 3

3.a

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Appendix 1



Geological profiles in Holtug Kridtbrud.



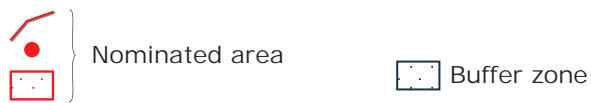
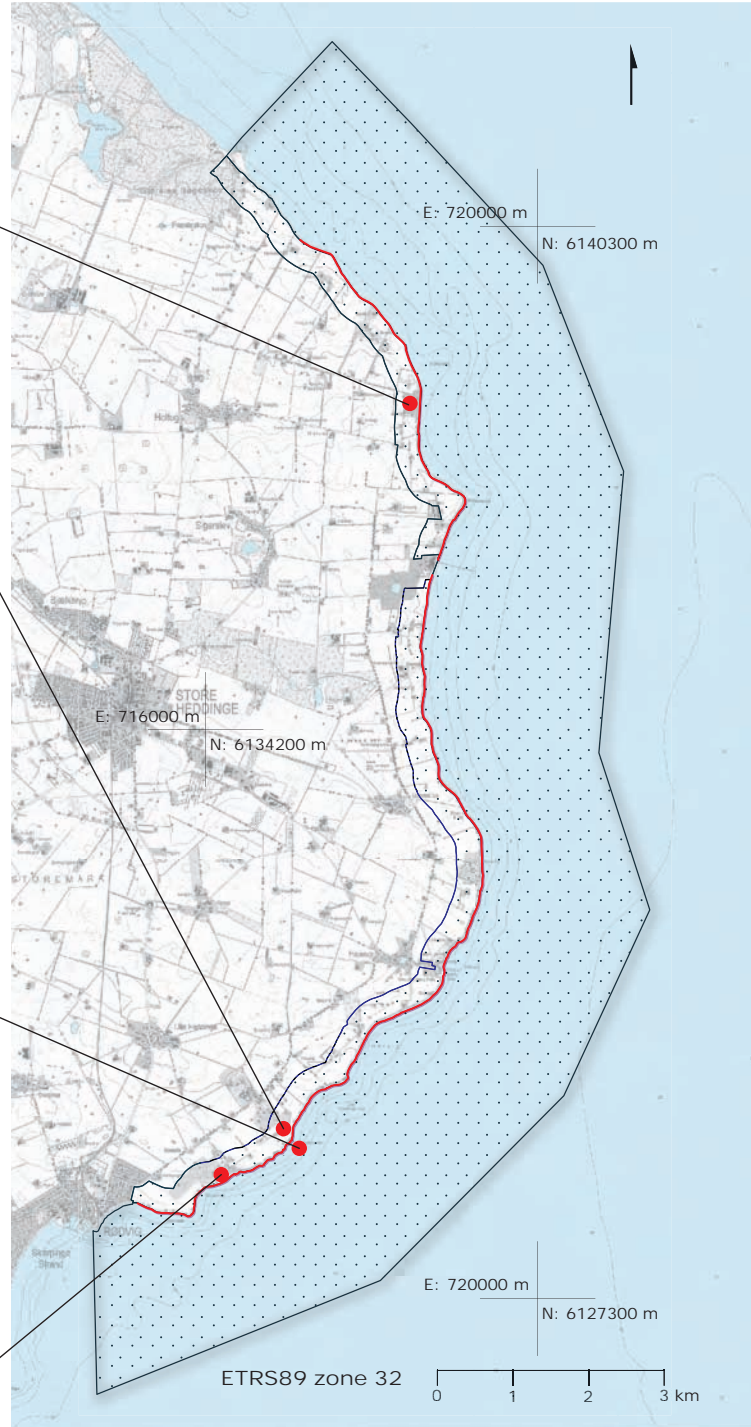
Tunnels in Cold War Fortress Stevnsfort.



Limestone mounds on seafloor.

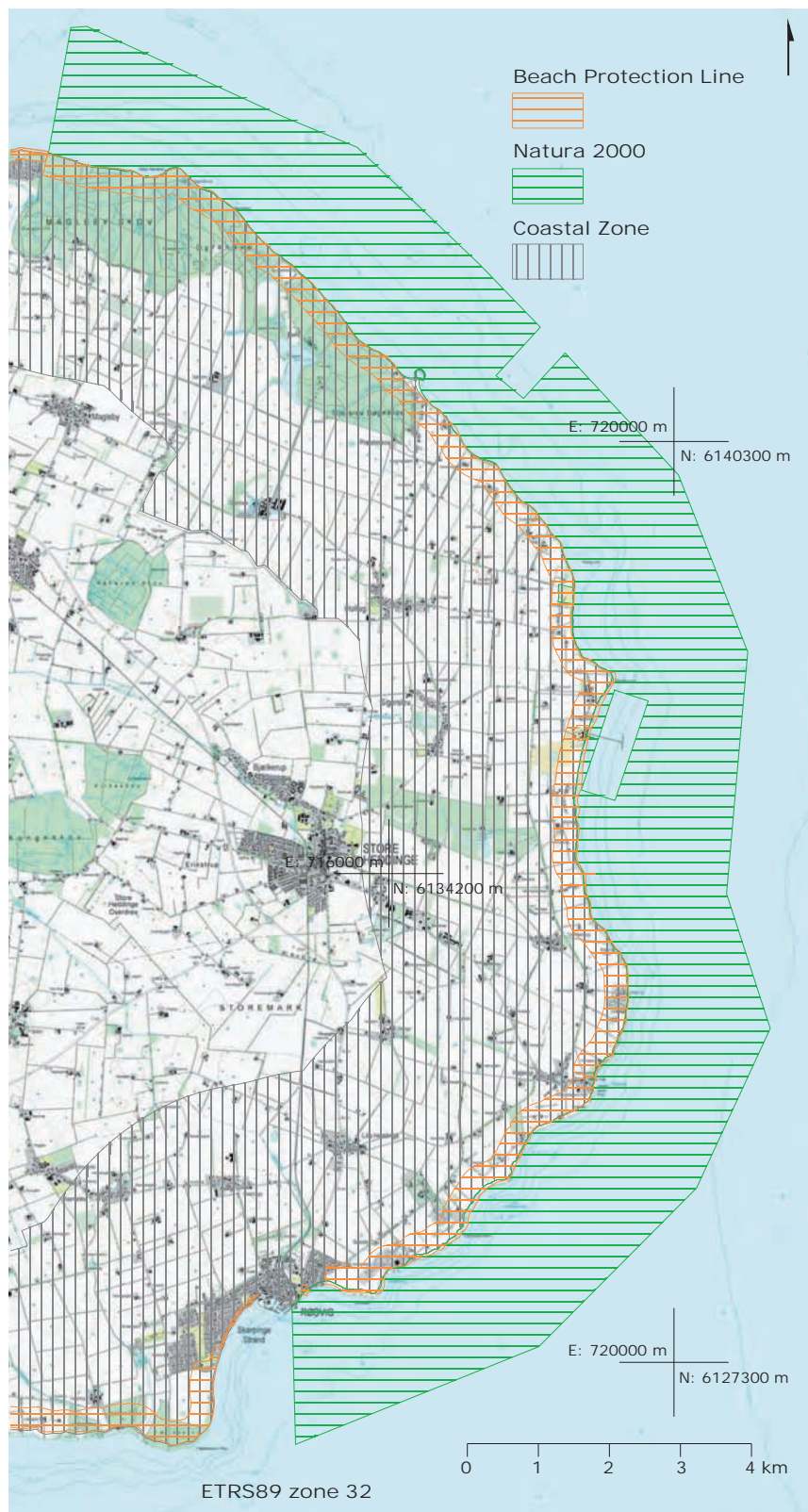


Geological profile at Boesdal Kalkbrud.



Topographic map showing the nominated area and buffer zone. The nominated area includes the coastal cliff (red line) and four adjacent areas marked on map (red dots) and shown in detail on inserted photographs.

NOMINATION OF STEVNS KLINT

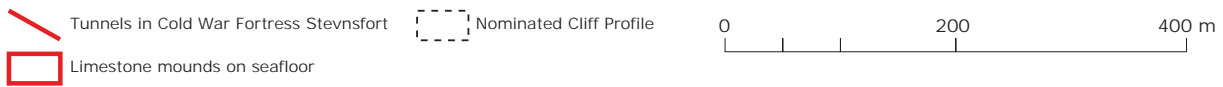


Topographic map showing the boundaries of existing areas of legal protection forming the basis for defining the buffer zone of the nominated Stevns Klint area.

NOMINATION OF STEVNS KLINT



Aerial photo showing boundaries of the nominated area in the abandoned quarry Holtug Kridtbrud.



Aerial photo showing boundaries of the nominated area on the seafloor and outline of the nominated tunnels of the Cold War fortress Stevnsfort.



NOMINATION OF STEVNS KLINT



Geological profile at Boesdal Kalkbrud



Nominated Cliff Profile

0 100 200 m

Aerial photo showing location of the nominated profile in the abandoned quarry Boesdal Kalkbrud.



Legislation

This Appendix contains translated extracts from Danish legislation that secures the nominated geological value as described in Section 5. The legislation text is available in full at www.retsinformation.dk (in Danish).

Act on Planning

Translated extracts from the Planning Act, Consolidated Act no. 937 of 24 September 2009.

The Act is available in full at www.retsinformation.dk. Part 2a.

Extract from Planning in coastal areas

Section 5a. The country's coastal areas shall be kept as free as possible of development and installations that do not need to be located near the coast.

Subsection 2. The Minister for the Environment shall monitor trends and make use of the powers granted in accordance with Section 3, Section 29 and Section 59 to ensure that the national planning interests in the coastal areas are furthered pursuant to this Act.

Subsection 3. The coastal zone, which comprises the rural zones and summer cottage areas located in the coastal areas, is shown in a map appended to this Act. The provisions of Section 5b, Section 11a, no. 18, Section 11e, subsection 1, no. 7 and subsection 2, Section 11f, Section 16, subsections 3 and 5, Section 29 and Section 35, subsection 3 shall apply to the coastal zone.

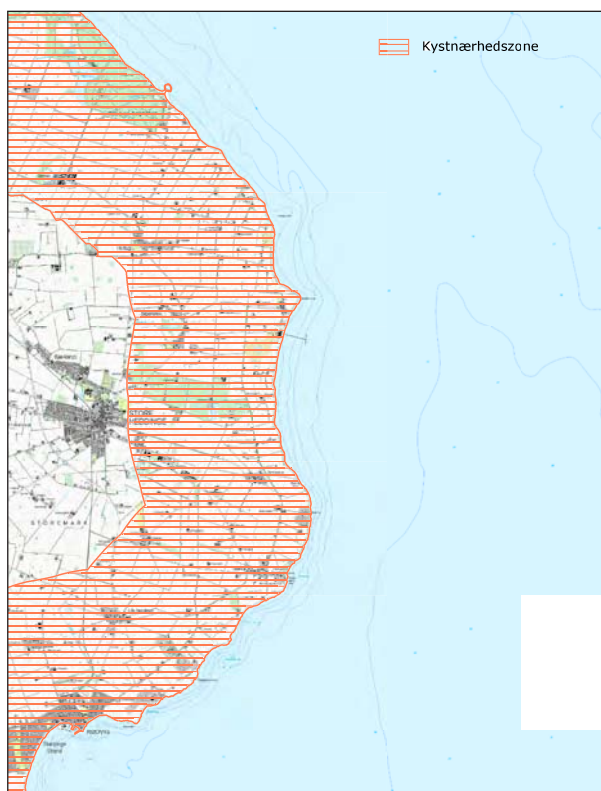
Section 5b. The following shall apply to planning in the coastal zone:

1) It is prohibited to transfer land to an urban zone or to conduct planning for development in a rural zone unless there is a specific planning-related or functional justification for location near the coast.

- 2) Except for harbour facilities used for transport and other very important infrastructural installations, development projects on land that require the reclamation of areas in the territorial waters or special coastal protection may only be planned in very special circumstances.
- 3) It is prohibited to designate new summer cottage areas, and existing summer cottage areas shall be maintained for holiday and leisure purposes, cf., however, subsection 2.
- 4) Holiday and leisure facilities shall be located in accordance with coherent considerations arising from tourism policy and only in connection with existing urban communities or large holiday and leisure facilities.
- 5) The access of the public to the coast shall be safeguarded and expanded.

Subsection 2. The Minister for the Environment may establish rules in accordance with Section 3, subsection 1, and subsection 2, item 1 that dispense from the provisions of subsection 1, no. 3, such that existing summer cottage areas within the coastal zone, and mainly in Denmark's small-town (peripheral) regions, may be expanded through the provisions of a local plan, when the expansion occurs behind a summer cottage area and in the direction away from the coast. Existing summer cottage areas may only be expanded outside areas governed by Section 8 and Section 15 of the Protection of Nature Act on dune conservation and beach protection and within a maximum of 8,000 new summer cottage lots in Denmark as a whole. In determining which summer cottage areas may be expanded, the Minister shall ensure that the expansion will not set aside important nature protection and landscape interests and that the expansion may be expected to affect the local economy.

NOMINATION OF STEVNS KLINT



The coastal zone protected by the Act on Planning.

Part 4

Extract from Municipal planning

Section 11. Each municipality shall have a municipal plan. The municipal plan shall cover a period of 12 years.

Section 11a. The municipal plan shall contain guidelines on:

- 15) securing the landscape assets worthy of conservation and the location of areas with valuable landscape features, including large, cohesive landscapes;
- 16) securing the geological assets worthy of conservation, including the location of areas with special geological value.

Act on the Protection of Nature

Translated extracts from the Protection of Nature Act, Consolidated Act no. 933 of 24 September 2009

The Act is available in full at www.retsinformation.dk.

Extract from Protection of coastal areas

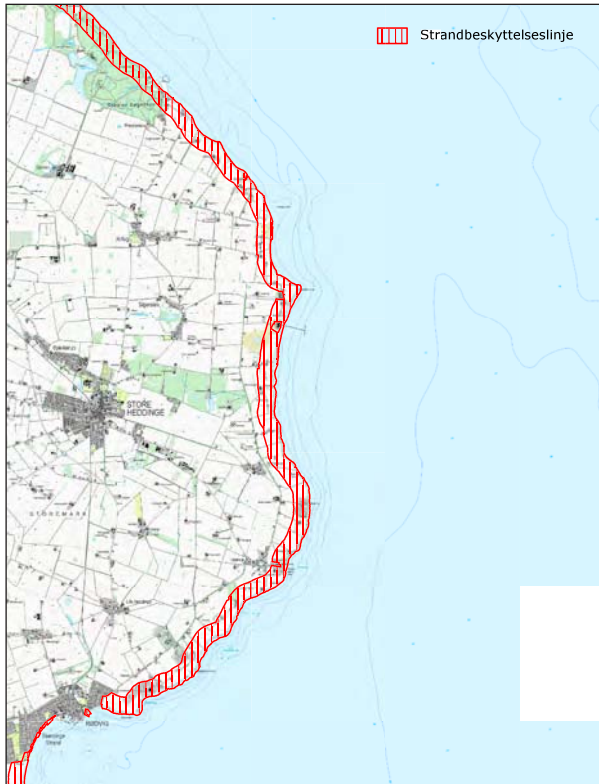
Section 15. It is prohibited to alter the state of beaches or other areas located between the beach and the beach protection line. It is also prohibited to erect fences and to place caravans or the like in such areas. Parcelling out, land registration and transfer of ownership of land whereby new boundaries are established shall be prohibited.

Subsection 2. The beach protection line shall be established at the direction of the Minister for the Environment in accordance with current regulations.

Subsection 3. The beach protection line shall be registered in the land register and noted in the land charges register.

Subsection 4. The prohibitions in subsection 1 shall not apply to:

- 1) agricultural operations except for afforestation;
- 2) reforestation and planting in existing gardens;
- 3) traditional fencing on agricultural properties;
- 4) existing defence installations that are used for defence purposes;
- 5) harbour installations and land areas designated for harbour purposes in local plans;
- 6) minor maintenance works on buildings, including the replacement of windows and roofs etc., when the building height is not increased thereby or is only increased to an insignificant degree;
- 7) buildings that are necessary for the commercial operation of the property in question as an agricultural or forestry property or for the execution of fishing industry, and which are erected immediately adjacent to existing buildings. However, the exact location and exterior design of the mentioned buildings shall be subject to permission from the Minister for the Environment, and
- 8) stretches of coast that are dune conservation areas, cf. Section 8 and Section 9.



The area between the beach and the beach protection line protected by the Act on the Protection of Nature.

Subsection 5. The Minister for the Environment may make regulations to the effect that subsection 1 shall not apply to specified types of structures that are also extended to territorial waters. The same applies to dikes and groynes, breakwaters and other structures that require a permit in accordance with the Act on Coastal Protection.

Museum Act

Translated extracts from the Museum Act, Consolidated Act no. 1505 of 14 December 2006.

The Act is available in full at www.retsinformation.dk.

Part 9

Extract from Treasure trove and fossil trove

Section 31. A geological object or a botanical or zoological object of a fossil or subfossil nature or a meteorite found in Denmark is fossil trove (danekræ) if the object is of unique scientific or exhibitional value.

Subsection 2. Fossil trove shall belong to the state. Any person who finds fossil trove, and any person who gains possession of fossil trove, shall immediately deliver it to the Natural History Museum of Denmark, cf. Section 9.

Subsection 3. The Natural History Museum of Denmark shall pay a reward to the finder. The amount shall be fixed by the Natural History Museum of Denmark having regard to the value of the material and the rarity of the find as well as to the care with which the finder has safeguarded the find.

Subsection 4. No fossil trove reward shall be paid to the finder if the fossil trove is found in connection with scientific investigations managed by a museum owned or subsidised by the state or otherwise financed, in whole or in part, by public funds. However, in special circumstances the Natural History Museum of Denmark may pay a reward to the owner or user of the area in which the investigation takes place.

Subsection 5. The object shall be included in the collections of the Natural History Museum of Denmark, and the Museum may deposit it in other museums owned or subsidised by the state at their request. Where agreement cannot be reached between the Natural History Museum of Denmark and another museum on the deposit of a new fossil trove find, the Minister for Culture shall decide after negotiation with the Minister for Science, Technology and Innovation.

Subsection 6. These provisions shall not apply to objects introduced to the area with aid from human beings.

Act on the Protection of Nature

Translated extracts from the Protection of Nature Act, Consolidated Act no. 933 of 24 September 2009.

The Act is available in full at www.retsinformation.dk.





NOMINATION OF STEVNS KLINT

Extract from Public access to nature. Beaches.

Section 22. Beaches and other stretches of coast between the daily low-water line and areas with continuous land vegetation that is not dominated by salt-resistant plants or other beach vegetation shall be open for passage on foot, occupancy for a short period of time and bathing. This access shall be at people's own risk. It shall be permitted to leave a boat without motor on the beach for a short period of time. Dogs must be leashed from 1 April to 30 September. Dogs must always be leashed in areas with grazing livestock. Horseback riding shall be permitted from 1 September to 31 May on the bare beach and on the direct approach to this, provided there is legal access to the beach.

Subsection 2. The provisions of subsection 1 do not apply to areas that were laid out as a garden or used by a commercial enterprise operating on the property before 1 January 1916. The same applies to defence installations and harbour installations.

Subsection 3. It is prohibited to prevent or obstruct public access to beaches.

Subsection 4. Occupancy and bathing shall not be allowed within 50 m of a residential building on privately owned beaches and stretches of coast.



Appendix 3



Inventory of Property

3.1 Fossils from Stevns Klint

List of micro- and macrofauna found at Stevns Klint

Kingdom *Animalia*

Subkingdom **Parazoa**
 Phylum **Porifera (Sponges)**
 Class **Calcarea (Calcareous sponges)**



Porosphaera adhaerens
Porosphaera applanata
Porosphaera canaliculata
Porosphaera foliata
Porosphaera galeata
 — *Porosphaera globularis*
Porosphaera nuciformis
Porosphaera ramosa
Porosphaera umbonata

Class **Demospongea (Demosponges)**



All Photo: Leif Rasmussen

Aulaxinia sulcifera
Cliona celata
 — *Doryderma?* sp.
Leiochonia? sp.
Pachythea insignis
Plinthosella squamosa
Seliscothion sp.
Siphonia sp. 1
Siphonia? sp. 2

Class **Stromatoporoidea (Stromatopods)**

Spinopora mitra

Class **Stromatoporoidea (Stromatopods)**

Genus et sp. indet. 1
 Genus et sp. indet. 2
 Genus et sp. indet. 3
 Genus et sp. indet. 4
 Genus et sp. indet. 5
 Genus et sp. indet. 6
 Genus et sp. indet. 7
 Genus et sp. indet. 8
 Genus et sp. indet. 9
 Genus et sp. indet. 10
 Genus et sp. indet. 11
 Genus et sp. indet. 12
 Genus et sp. indet. 13

Phylum **Silicispongea (Silica sponges)**
 Class **Hexactinellida (Glass sponges)**



Wollemania? sp.
Aphrocallistes sp.
Hapalopegma? sp.
Leptophragma sp.
 Triaxonid sponge
 — *Ventriculites radiatus*
Ventriculites sp. 1
Ventriculites? sp. 2

Kingdom *Animalia*

Subkingdom **Metazoa**
 Phylum **Cnidaria**
 Class **Scyphozoa (Jellyfish)**

Genus et sp. indet.

Class **Anthozoa (Sea anemones and corals)**



— *Desmophyllum excavatum*
Gorgonella tenuis
Graphularia sp. 1
Graphularia sp. 2
Isis steenstrupi
Moltkia isis
Moltkia sp.
Parasmilia cylindrica
Parasmilia elongata
Parasmilia parva
Trochocyathus hemisphaericus

Phylum **Bryozoa (Bryozoans)**
 Class **Stenolaemata**
 Order **Cystoporida**

Taeniopora articulata

Class **Stenolaemata**
 Order **Cyclotomata**



Bisidmonea johnstrupi
 — *Canalipora disticha*
Canalipora gutta
Crassodiscopora alcicornis
Crisidmonea macropora
Crisina cancellata
Crisina lichenoides
Crisina carinata
Crisina gibbosa
Desmepora semicylindrica
Diastopora carinata
Diastopora cf. *compressa*
Diastopora horrida



- Diastopora levinseni*
- Diastopora pustulosa*
- Diastopora? subreniformis*
- Diplopetalopora punctata*
- Diplosolen limhamnina*
- Discotubigera complanata*
- Disporella irregularis*
- Epidictyon tenue*
- Filisparsa microstoma*
- Idmidronea globulosa*
- Idmidronea suecica*
- Idmonea cf. ramosa*
- Lichenopora stevensis*
- Meliceritella verticellata*
- Multicavea? sp.*
- Nevianopora subgracilis*
- Osculipora truncata*
- Petalopora marssoni*
- Pseudotervia ramosa*
- Pustulopora geminata*
- Pustulopora klostergaardi*
- Pustulopora rustica*
- Pustulopora variabilis*
- Pustulopora virgula*
- Radiopora? sp.*
- Reticulipora verriculata*
- Silenopora reticulata*
- Spiropora verticellata*
- Stigmatoechos punctatus*
- Stomatopora irregularis*
- Stomatopora longiscata*
- Stomatopora reticulata*
- Stomatopora toucasiana*
- Theonoea disticha*

Class **Gymnolaemata**
Order **Cheilostomata**

- Aechmella microstoma*
- Aechmella pindborgi*
- Amphiblestrum elegans*
- Andriopora repens*
- Anornithopora minuta*
- Aplousina fulgora*
- Aplousina oedumi*
- Beisselina nobilis*
- Beisselinopsis oblita*
- Callopora acuminella*
- Callopora cf. lyraeformis*
- Callopora monocera*
- Callopora securigera*
- Callopora stefniensis*
- Callopora unipora*
- Cellepora daniensis*
- Columnotheca cribrosa*
- Coscinopleura angusta angusta*
- Cribrilina inermis*
- Cribrilina sparsipora*



- Cryptostomella pectinata*
- Ellisina britannica*
- Ellisina humiliata*
- Fissuricella fissa*
- Floridina fragilis*
- Floridina gothica*
- Floridina impar*
- Floridina impressipora*
- Floridina impressipora var. faxensis*
- Floridina scutata*
- Floridina tubulosa*
- Frurionella sp.*
- Hoplitaechmella vespertilio*
- Kelestoma elongatum*
- Lateroflustraria hexagona*
- Luganella beisseli*
- Luganella foveolata*
- Lunularia goldfussi*
- Lunulites faxensis*
- Lunulites immensa*
- Lunulites microstoma*
- Lunulites salebrosa*
- Lunulites semilunaris*
- Lunulites spiralis*
- Lunulites subsemilunaris*
- Membranipora calceolus*
- Membranipora crustulenta*
- Membranipora gigantea*
- Membranipora hexagona*
- Membranipora impressa*
- Membranipora johnstrupi*
- Membranipora magnispina*
- Membranipora marssoni*
- Membranipora marssoniana*
- Membranipora plicatelloides*
- Membranipora sparsispina*
- Membranipora trigonopora*
- Membraniporella rapax*
- Membraniporella squamulosa*
- Micropora amphora var. elongata*
- Micropora erecta var. b*
- Micropora erratica*
- Micropora stevensis*
- Micropora strumulosa*
- Monoceratopora quadrisulcata*
- Monoporella bosqueti*
- Monoporella dubiosa*
- Mucronella hians*
- Murinopsia galeata*
- Onychocella columella*
- Onychocella dichotoma*
- Onychocella gimense*
- Onychocella nodulifera*
- Onychocella nysti*
- Onychocella poulsenii*
- Pachydera angulata*
- Pachydera densa*
- Pachythercella anhaltina*

NOMINATION OF STEVNS KLINT



Pachythecella lundgreni
Phractoporella cordiformis
Phractoporella sp.
Pithodella cincta
Pliophloea cornuta
Pliophloea subcornuta
Porina cylindrica
Porina salebrosa
Puncturiella sculpta
Rhiniopora asperula
Semiescharinella complanata
Smittipora prismatica
Stamenocella pristis
Stichocados subbrachiata
Stichopora pentasticha
Systemostoma verticillata
Tornipora harvigensis
Tricephalopora cerberus
Tricephalopora crepidula
Tricephalopora galeata
Tricephalopora triceps
Virgocella esperi
Woodipora disparilis



Cretirhynchia plicatilis
Cretirhynchia retracta
Cretirhynchia sp.
Gemmarcula humboldtii
Gisilina gisii
Gisilina jasmundi
Kingena pentangulata
Magas chitoniformis
Meonia semiglobularis
Neolothyrina fittoni
Neolothyrina obesa
Rugia tenuicostata
Scumulus inopinatus
Terebratula fallax
Terebratula mobergi
Terebratulina aff. *chrysalis*
Terebratulina chrysalis
Terebratulina faujasii
Terebratulina gracilis
Terebratulina longicollis
Thecidea pappilata
Thecidea recurvirostra
Trigonosomus pulchellum
Vermiculothecidea vermicularis

Phylum **Brachiopoda (Lampshells/brachiopods)**
 Subphylum **Linguiformea**
 Class **Lingulata**

Lingula cretacea
Discinisca? sp.

Subphylum **Craniiformea**
 Class **Craniata**



Ancistrocrania tubulosa
Crania aff. *craniolaris*
Crania antiqua
Crania transversa
Danocrania tuberculata
Isocrania barbata
Isocrania costata
Isocrania sp.

Subphylum **Rhynchonelliformea**
 Class **Rhynchonellata**

Aemula inusitata
Argyrotheca brononii
Argyrotheca danica
Argyrotheca faxensis
Argyrotheca hirundo
Argyrotheca posselti
Argyrotheca ravnii
Argyrotheca stevensis
Carneithyris sp.
Carneithyris subcardinalis
Cretirhynchia faxensis
Cretirhynchia limbata

Phylum **Annelida (Segmented worms)**
 Class **Polychaeta**



Bipygmaeus pygmaeus
Cementula applanata
Conorca trochiformis
Filograna? sp.
Filogranula cincta
Glomerula gordialis
Martina tortilis
Metaveremia (Vepreculina) tuberculifera
Neomicrorbis corrugata
Neomicrorbis crenatostratus aff. *hagenowi*
Neomicrorbis crenatostratus hagenowi
Neomicrorbis crenatostratus subrugosus
Neomicrorbis expansa
Neomicrorbis rosenkrantzi
Neomicrorbis subrugosus
Neomicrorbis tenuilineata
Neovermilia ampullacea
Neovermilia indistincta
Neovermilia sp.
Neovermilia terundulata
Nogrobs (Tetraditrupe) canteriata
Nogrobs (Tetraditrupe) superiora
Orthoconorca turricula
Pentaditrupe subtorquata
Placostegus? sp.
Pyrgopolon (Septenaria) cicatricata



Pyrgopolon (Septenaria) macropus
Rotularia sp.
Serpula? sp.
Vermiliopsis dorsolineata
Vermiliopsis fluctuata

Phylum **Mollusca (Mollusks)**
 Class **Bivalvia (Bivalves)**

Acutostrea incurva
Anomia pseudoradiata
Arca (Eonavicula) granuloradiata
Arcoida sp.
Arcopsis (Arcopsis) christinae
Astarte sp.
Atreta nilssoni
Barbatia (Acar) hennigi
Barbatia (Barbatia) forchammeri
Barbatia (Obliquarca?) lindae
Bathyarca perla
Birkelundita turoniensis
Brachidontes lineatus
Brachidontes sp.
Catella katinkae
Corbulamella sp.
Crassatella faxensis
Cuspidaria (Cuspidaria) bentzonii
Cuspidaria (Cuspidaria) brittae
Cuspidaria (Cuspidaria) caudata
Cuspidaria (Cuspidaria) johannae
Cuspidaria (Cuspidaria) lisbethae
Cuspidaria (Halonympha) kanae
Cuspidaria sp. 1
Cuspidaria sp. 2
Cuspidaria sp. 3
Cyrtodaria? sp.
Dacrydium sp.
Dhondtichlamys acuteplicatus
Dhondtichlamys campaniensis
Dhondtichlamys pulchellus
Dhondtichlamys subinflexus
Entolium membranaceum
Eriphylopsis? sp.
Erycina? sp.
Euciroa sp. 1
Euciroa sp. 2
Freyastarte sp.
Gastrochaena sp.
Gervillia (Gervillia) solenoidea
Granocardium productum
Gregariella sp.
Gyroleura sp.
Hytissa semiplana
Jouanettia sp.
Leptosolen sp.
Limatula decussata
Limatula kunradensis



Limea geinitzi
Limopsis aff. *maggae*
Limopsis aff. *ravni*
Limopsis alvidae
Limopsis amandae
Limopsis augustae
Limopsis helenae
Limopsis magdae
Limopsis maggae
Limopsis nanae
Limopsis ravni
Limopsis sacheri
Limopsis sp.
Loripes sp.
Lucinidae gen. et sp. indet.
Lucinoma subnumismalis
Martesia sp.
Meiocardia faxensis
Meiocardia sp.
Meiocardiopsis sp.
Merklinia variabilis
Mimachlamys cretosa
Mutiella coarctata?
Myoconcha sp.
Myrtea? sp.
Neilonella aff. *foersteri*
Neilonella susannae
Neithea (Neithea) sexcostata
Nucula (Nucula) aff. truncata
Nucula (Nucula) sp.
Oxytoma (Hypoxytoma) danica
Panopea sp.
Pholadomya sp.
Pinna cretacea
Placunopsis granulosa
Plagiostoma cretacea
Plagiostoma hoperi
Prosilicula parallellodonta
Protocardia sp.
Pseudogrammatodon lornae
Pseudolimea denticulata
Pseudolimea? granulata
Psilomya sp.
Pycnodonte (Phygraea) vesicularis
Rastellum diluvianum
Sita sp.
Spondylus danicus
Spondylus faxensis
Spondylus fimbriatus
Spondylus latus
Spondylus truncatus
Syncyclonema haggi
Syncyclonema nilssoni
Tenuipteria argentea
Thracia? sp.
Thyrasira sp.
Uddenia? sp.
Unicardium? sp.



All Photo: Laili Rasmussen



NOMINATION OF STEVNS KLINT



Verticordia sp.
Vetericardiella sp.
Vultogryphaea? sp.
 "Yoldia" sp.
Yoldiella anja
Yoldiella dortea
 Genus et sp. indet. 1
 Genus et sp. indet. 2
 Genus. et sp. indet. 3
 Genus et sp. indet. 4
 Genus et sp. indet. 5
 Genus et sp. indet. 6
 Genus et sp. indet. 7
 Genus et sp. indet. 8
 Genus et sp. indet. 9
 Genus et sp. indet. 10
 Genus et sp. indet. 11
 Genus et sp. indet. 12
 Genus et sp. indet. 13
 Genus. et sp. indet. 14
 Genus et sp. indet. 15
 Genus et sp. indet. 16



Class **Gastropoda (Snails/Gastropods)**

Acirsa sp. 1
Acirsa sp. 2
Acmaea sp. 1
Acmaea? sp. 2
Admetula sp.
Ageria sp. 1
Ageria sp. 2
Alvania (Alvania?) sp.
Amaea (Amaea) sp. 1
Amaea sp. 2
Amalda milthersii
Amaurellina sp.
Anatoma sp. 1
Anatoma? sp. 2
Anchura sp.
Archicypraea sp.
Arene sp.
Ataphrus (Ataphrus) sp. 1
Ataphrus (Ataphrus) sp. 2
Ataphrus? sp. 3
Ataxocerithium sp. 1
Ataxocerithium? sp. 2
Babylonella sp.
Bathrotomaria sp.
Bathybembix? sp.
Calliomphalus (Calliomphalus) sp.
Calyptraea sp.
Campanile selandicum
 — *Campanile* sp. 1
Campanile sp. 2
Carinathilda sp.
Ceratia sp. 2
Ceratia? sp. 1



Cerithiella moltkianum
Cerithiella sp. 1
Cerithiella? sp. 2
Cerithiopsilla? sp.
Cerithiopsis sp. 1
Cerithiopsis? sp. 2
Cerithiscala sp.
Cerithium sp.
Chilodonta sp. 1
Cirsocerithium crassilabris
Clathrobaculus sp.
Claviscala sp.
Cocculina (Cocculina) s.l. sp.
Columbarium heberti
Cumbellaria tuberculosa
Coniscala sp. 1
Coniscala sp. 2
 — *Conomitra glabra*
Costellariid gen. et sp. indet. 1
Costellariid gen. et sp. indet. 2
Costellariid gen. et sp. indet. 3
Costellariid gen. et sp. indet. 4
Cylichna sp. 3
Cylichna sp. 4
Cylichna? sp. 1
Cylichna? sp. 2
Dendropoma sp.
Disculus selandicum
Dolicholatirus sp.
Dzikella? sp.
Ellipsoscapha? sp.
Emarginula (Emarginula) coralliora
Epalxis? sp.
Epetrium? sp.
Eulima? *danica*
Eulima? sp. 1
Eumetula sp.
Fissurellid gen. et sp. indet.
Fusinus sp.
Galericulus sp.
Haustator cf. *plana*
Homalopoma sp.
Kroisbachia sp.
Latirulus? sp.
Laxispira sp.
Leptomaria meyeri
Leptomaria niloticiformis
Loxotoma sp.
Mangelia? sp.
Mataxa s.l. sp.
Melanela? sp. 1
Mesalia sp. 1
Mesalia? sp. 2
 — *Metacerithium balticum*
Natica sp. 1
Natica sp. 2
Opaliopsis sp.
Pareuchelus sp.



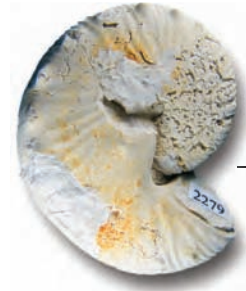
- Polinices?* sp. 1
- Polinices?* sp. 2
- Pseudocochlespira* sp.
- Pseudomalaxis* sp.
- Pseudotoma* sp.
- Pseudovertagus?* sp.
- Ravniella danica*
- Rissoina (Zebinella)* sp. 1
- Rissoina* sp. 2
- Rissoina* sp. 3
- Sassia (Sassia) faxensis* s.l.
- Scissurella* sp.
- Serpulorbis* sp.
- Skenea* sp.
- Solariella* sp.
- Sorgenfreispira?* sp.
- Streptochetus* sp.
- Striovertagus?* sp.
- Sveltella* sp.
- Symmetrocapulus?* sp.
- Tatara* sp. 1
- Tatara* sp. 2
- Tectus* sp.
- Temnotropis* sp.
- Tenagodus* sp.
- Thereitis* sp. 1
- Thereitis* sp. 2
- Thereitis* sp. 3
- Torina (Climacopoma)?* sp.
- Trochocerithium* sp.
- Turricula (Orthosurcula)*
cerithiorum
- Turritella?* sp.
- Unitas* sp.
- Vatopsis* sp. 1
- Vatopsis* sp. 2
- Vermetus* sp.
- Vexillum* sp.
- Volutidae* gen. et sp. indet.
- Volutomitra* cf. *quinqueplicata*
- Genus et sp. indet. 1
- Genus et sp. indet. 2
- Genus et sp. indet. 3
- Genus et sp. indet. 4
- Genus et sp. indet. 5
- Genus et sp. indet. 6
- Genus et sp. indet. 7
- Genus et sp. indet. 8
- Genus et sp. indet. 9
- Genus et sp. indet. 10
- Genus et sp. indet. 11
- Genus et sp. indet. 12

Class **Scaphopoda (Tusk shell)**

Dentalium sp.



Class **Cephalopoda (Cephalopods)**



- Acanthoscaphites* sp.
- Baculites vertebralis*
- Belemnella* aff. *occidentalis*
- Belemnella casimirovensis*
- Belemnitella junior*
- Diplomoceras cylindraceum*
- Eutrephoceras* aff. *bellerophon*
- Hercoglossa danica*
- Hoploscaphites constrictus crassus*
- Hoploscaphites constrictus johnjagti*
- Hypophylloceras (Neophylloceras)*
velledaeforme
- Menuites terminus*
- Pachydiscus* aff. *colligatus*
- Phylloptychoceras (Phyllopty-*
choceras) sp.
- Saghalinites* sp.
- Sphenodiscus* sp.

- Phylum **Arthropoda (Arthropods)**
- Subphylum **Crustacea (Crustaceans)**
- Class **Malacostraca**
- Order **Decapoda**



Photo: Sten Lemmer, Jakobben

- Callianassa* sp.
- Caloxanthus ornatus*
- Dromiopsis elegans*
- Dromiopsis laevior*
- Dromiopsis rugosa*
- Faxegalathea platyspinosa*
- Linuparus* sp.
- Munida primaeva*
- Necrocarcinus senonensis*
- Necrocarcinus* sp.
- Oncopareia* sp.

Order **Isopoda**

- Palaega danica*
- Palaega* sp.

Class **Decapoda**

Titanocarcinus faxeensis

Class **Maxillopoda**
Infraclass **Cirripedia (Barnacles)**



- Arcoscalpellum maximum* var.
sulcatum
- Brachylepas* sp.
- Cretiscalpellum/Arcoscalpellum* sp.
- Pollicipes* sp.

NOMINATION OF STEVNS KLINT



Phylum **Echinodermata (Echinoderms)**
 Subphylum **Crinozoa**
 Class **Crinoidea (Sea lilies)**

Amphorometra conoidea
Bourgueticrinus constrictus
Bourgueticrinus danicus
Bourgueticrinus hagenowii
Democrinus? maximus
Doreckicrinus miliaris
Hertha plana
Isocrinus? echinatus
Isselicrinus buchii
Isselicrinus paucirrhus
Isselicrinus stelliferus
 — *Nielsenicrinus agassizii*
Nielsenicrinus rosenkrantzi



Photo: Leif Rasmussen

Echinocorys pustolosus pustolosus
Echinocorys scutatus
Echinothuria? sp.
Galeaster bertrandi
Galerites sulcatoradiatus
Gauthieria alterna
Gauthieria pseudoradiata
Oolopygus crassus
Phymosoma granulosum
Salenia (Pleurosalenia) anthophora
Salenia (Pleurosalenia) pygmaea
Salenia (Salenia) belgica
Temnocidaris (Stereocidaris) aff. subvesiculosa
Temnocidaris (Stereocidaris) arnaudi
Temnocidaris (Stereocidaris) herthae
Temnocidaris (Stereocidaris) sp. 1
Temnocidaris (Stereocidaris) sp. 2
Temnocidaris (Temnocidaris) danica
Temnocidaris (Temnocidaris) nigelliensis
Trochalosoma taeniatum
Tylocidaris abildgaardii
Tylocidaris baltica
Tylocidaris bruennichi
Tylocidaris hardouini
Tylocidaris sp.



Photo: Leif Rasmussen

Subphylum **Asterozoa**
 Class **Asterozoa (Starfish)**

Chomataster acules
Crateraster anchylus
Crateraster favosus
Lophidiaster pygmaeus
Lophidiaster? punctatus
Metopaster kagstrupensis
Metopaster laevis
Metopaster planus
Metopaster poulsenii
Metopaster spencerii
Metopaster undulatus
Nymphaster wrighti
Pycinaster sp.
Recurvaster mammillatus
 — *Recurvaster radiatus*
Stauranderaster mixtus
Stauranderaster pyramidalis
Stauranderaster speculum
Valettaster ocellatus



Photo: Leif Rasmussen

Class **Ophiurozoa (Brittle stars)**

Ophiocoma? senonensis
Ophiomusium granulosum
Ophiotitanos serrata
Stegophiura? hagenowii
Trichaster? ornatus

Class **Echinozoa (Sea urchins)**

Cardiotaxis heberti
Centrostephanus? sp.
Cidaris? rosenkrantzi
Conulus magnificus
Cyclaster bruennichi
Cyclaster danicus
Echinocorys pustolosus daniensis

Phylum **Chordata (Chordates)**
 Class **Elasmobranchii (Sharks)**

Anomotodon plicatus
Carcharias gracilis
Carcharias sp.
Centroscymnus praecursor
Chlamydoselachus sp.
Crassescyliorhinus germanicus
 — *Cretalamna appendiculata*
Hemisicyllium hermani
Heptranchias sp.
Heterodontus rugosus
Heterodontus sp.
Hexanchus microdon
Jaekelotodus cf. bronni
Notidanodon lanceolatus
Odontaspis winkleri
Palaeobrachaelurus sp.
Palaeogaleus sp.
Paraorthacodus andersoni
Paraorthacodus sp.
Pararhincodon groessensis
Parasquatina cappelletti
Paratriakis curtirostris
Proetmopterus hemmooriensis
Pseudocorax affinis
Scyliorhinus biddlei
Scyliorhinus elongatus



Photo: Jan Adalpaan



Photo: Jan Schulz Abdelfissen

- Serratolamna* sp.
- Sphenodus lundgreni*
- Squalicorax pristodontus*
- Squaliodalatias* sp.
- Squalus gabrielsoni*
- Squalus* sp.
- Squalus* sp.
- Squatina cranei*
- Squatina hassei*
- Squatina* sp.
- Squatirhina lonzeensis*
- Striatolamna* sp.
- Synechodus faxensis*
- Synechodus* sp.
- Triakidae
- Weltonia* sp.



Photo: Lief Roarumoen

Class **Achipterygii (Ray-finned fish)**

- Actinopterygii* gen. et sp. indet. 1
- Actinopterygii* gen. et sp. indet. 2
- Anguilliformes* gen. et sp. indet.
- Enchodus* sp.
- Osteoglossiformes* gen. et sp. indet.

Order **Acipenseriformes**

- Acipenseridae cylindracanthus*

Class **Reptilia (Mosasaurus)**

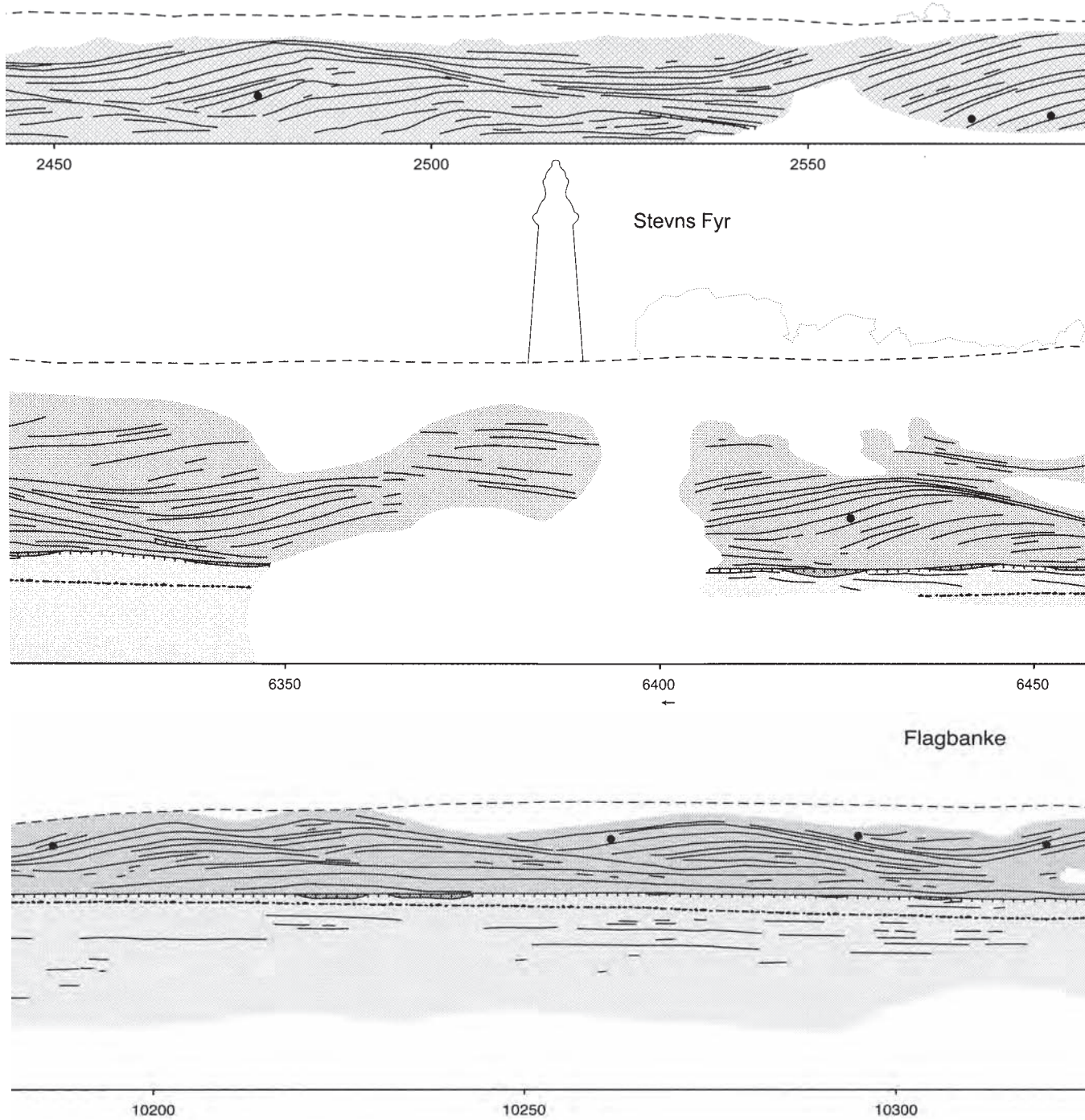
- Mosasaurus hoffmanni*
- Plioplatecarpus* sp.



NOMINATION OF STEVNS KLINT

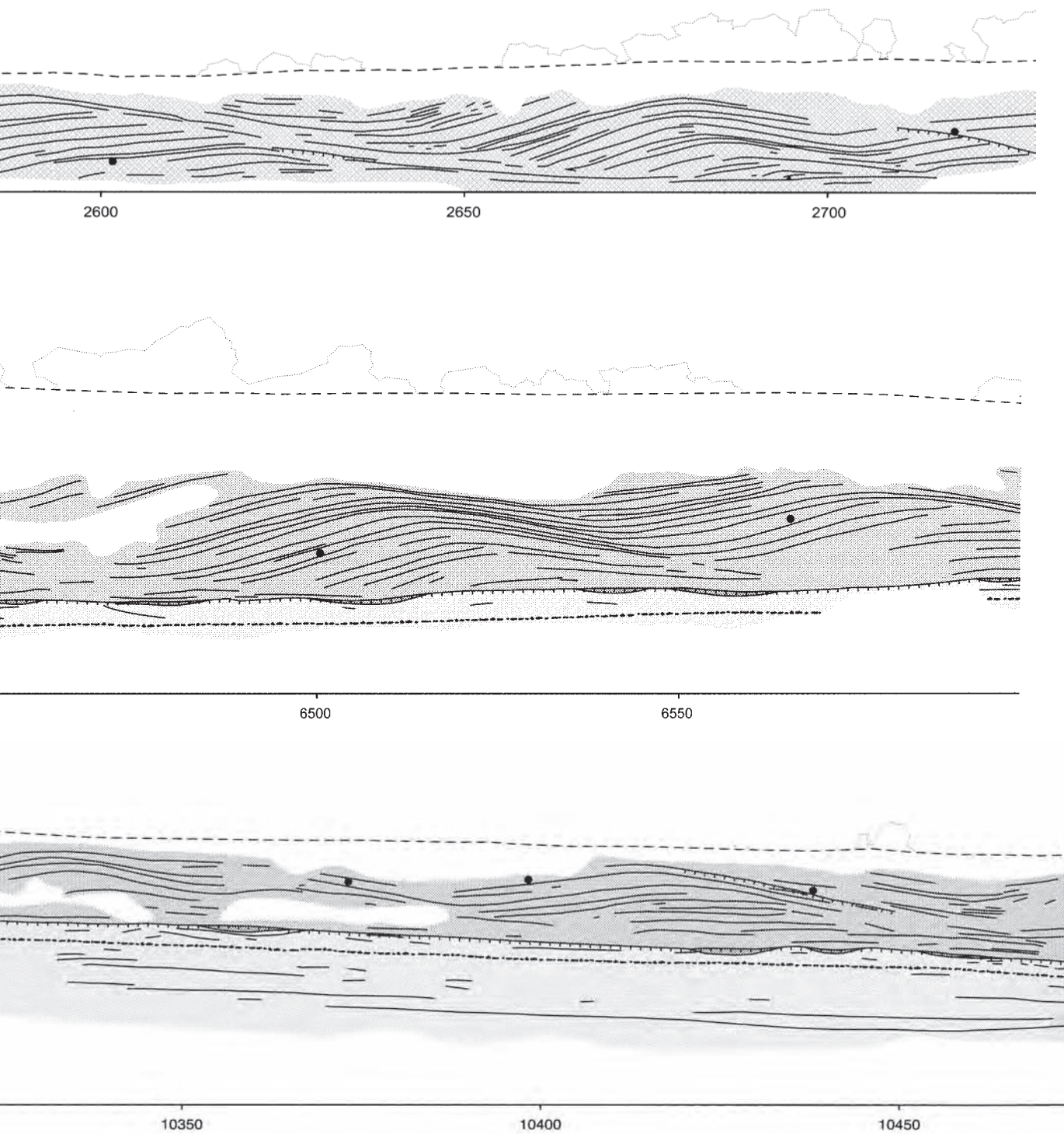
3.2 Geological profile of Stevns Klint

Lille Hedde





dinge Vig



Three short sections illustrating the character of the complete geological profile of Stevns Klint from Surlyk et al. 2006 illustrating the outline of the Cretaceous–Tertiary boundary and the flint layers of the Cretaceous chalk and the Danian bryozoan limestone. The shown sections cover c. 800 m of the 15,500 m long profile.



3.3 Birds at Stevns Klint

Species

Carduelis hornemanni
Sterna paradisaea
Aquila heliaca
Tyto alba
Hirundo rustica
Branta leucopsis
Sylvia nisoria
Limosa lapponica
Anser fabalis
Panurus biarmicus
Cephus grylle
Milvus migrans

English name

Arctic Redpoll
Arctic Tern
Asian Imperial Eagle
Barn Owl
Barn Swallow
Barnacle Goose
Barred Warbler
Bar-tailed Godwit
Bean Goose
Bearded Tit
Black Guillemot
Black Kite



Bird of Prey.

Phoenicurus ochruros
Melanitta nigra
Ciconia nigra
Chlidonias niger
Dryocopus martius
Oenanthe hispanica
Rissa tridactyla
Gavia arctica
Himantopus himantopus
Cyanistes caeruleus
Luscinia svecica
Bombycilla garrulus
Aquila pennata
Fringilla montifringilla
Branta bernicla
Limicola falcinellus
Corvus corone
Larus cachinnans

Black Redstart
Black Scoter
Black Stork
Black Tern
Black Woodpecker
Black-eared Wheatear
Black-legged Kittiwake
Black-throated Diver
Black-winged Stilt
Blue Tit
Bluethroat
Bohemian Waxwing
Booted Eagle
Brambling
Brent Goose
Broad-billed Sandpiper
Carrion Crow
Caspian Gull

Hydroprogne caspia
Motacilla citreola
Periparus ater
Ficedula albicollis
Turdus merula
Chroicocephalus ridibundus
Buteo buteo
Fringilla coelebs
Phylloscopus collybita
Grus grus
Cuculus canorus
Somateria mollissima
Bucephala clangula
Locustella naevia

Tringa nebularia
Delichon urbicum
Falco tinnunculus
Alcedo atthis
Carduelis cannabina
Mergus merganser
Gallinula chloropus
Uria aalge
Phasianus colchicus
Columba livia
Aythya ferina
Coturnix coturnix
Carduelis flammea
Tringa totanus
Phoenicurus phoenicurus
Emberiza schoeniclus
Charadrius hiaticula
Carpodacus erythrinus
Actitis hypoleucos
Tadorna tadorna
Gallinago gallinago
Sturnus vulgaris
Apus apus
Sterna hirundo
Sylvia communis
Columba palumbus
Emberiza calandra
Calidris ferruginea
Calidris alpina
Prunella modularis
Alopochen aegyptiaca
Sylvia atricapilla
Pyrrhula pyrrhula
Streptopelia decaocto
Fulica atra
Numenius arquata
Charadrius morinellus
Falco subbuteo
Garrulus glandarius
Pica pica
Sitta europaea
Haematopus ostralegus
Remiz pendulinus
Ficedula hypoleuca
Glaucidium passerinum
Acrocephalus scirpaceus
Anthus petrosus
Carduelis spinus

Caspian Tern
Citrine Wagtail
Coal Tit
Collared Flycatcher
Common Blackbird
Common Black-headed Gull
Common bBuzzard
Common Chiffchaff
Common Chiffchaff
Common Crane
Common Cuckoo
Common Eider
Common Goldeneye
Common Grasshopper Warbler
Common Greenshank
Common House Martin
Common Kestrel
Common Kingfisher
Common Linnet
Common Merganser
Common Moorhen
Common Murre
Common Pheasant
Common Pigeon
Common Pochard
Common Quail
Common Redpoll
Common Redshank
Common Redstart
Common Reed Bunting
Common Ringed Plover
Common Rosefinch
Common Sandpiper
Common Shelduck
Common Snipe
Common Starling
Common Swift
Common Tern
Common Whitethroat
Common Wood Pigeon
Corn Bunting
Curlew Sandpiper
Dunlin
Dunnock
Egyptian Goose
Eurasian Blackcap
Eurasian Bullfinch
Eurasian Collared Dove
Eurasian Coot
Eurasian Curlew
Eurasian Dotterel
Eurasian Hobby
Eurasian Jay
Eurasian Magpie
Eurasian Nuthatch
Eurasian Oystercatcher
Eurasian Penduline Tit
Eurasian Pied Flycatcher
Eurasian Pygmy Owl
Eurasian Reed Warbler
Eurasian Rock Pipit
Eurasian Siskin

Photo: T. W. Johansen



Alauda arvensis
Accipiter nisus
Saxicola torquatus
Anas crecca
Passer montanus
Certhia familiaris
Anas penelope
Scelopax rusticola
Troglodytes troglodytes
Jynx torquilla
Merops apiaster
Pluvialis apricaria
Carduelis carduelis
Carduelis chloris
Pernis apivorus
Erithacus rubecula
Serinus serinus
Streptopelia turtur
Turdus pilaris
Regulus ignicapilla
Anas strepera
Sylvia borin
Anas querquedula
Larus hyperboreus
Regulus regulus
Aquila chrysaetos
Oriolus oriolus
Phalacrocorax carbo
Podiceps cristatus
Ardea alba
Lanius excubitor
Gavia immer
Stercorarius skua
Dendrocopos major
Parus major
Larus marinus
Branta canadensis
Aythya marila
Aquila clanga
Anser albifrons
Tringa ochropus
Phylloscopus trochiloides
Ardea cinerea
Perdix perdix
Pluvialis squatarola
Motacilla cinerea
Anser anser
Falco rusticolus
Coccythraustes coccythraustes
Larus argentatus
Corvus cornix
Podiceps auritus
Eremophila alpestris
Passer domesticus
Phylloscopus humei
Hippolais icterina
Somateria spectabilis
Calcarius lapponicus
Larus fuscus
Carduelis cabaret
Aquila pomarina
Dendrocopos minor
Sylvia curruca

Eurasian Skylark
Eurasian Sparrowhawk
Eurasian Stonechat
Eurasian Teal
Eurasian Tree Sparrow
Eurasian Treecreeper
Eurasian Wigeon
Eurasian Woodcock
Eurasian Wren
Eurasian Wryneck
European Bee-eater
European Golden Plover
European Goldfinch
European Greenfinch
European Honey-buzzard
European Robin
European Serin
European Turtle Dove
Fieldfare
Firecrest
Gadwall
Garden Warbler
Garganey
Glaucous Gull
Goldcrest
Golden Eagle
Golden Oriole
Great Cormorant
Great Crested Grebe
Great Egret
Great Grey Shrike
Great Northern Diver
Great Skua
Great Spotted Woodpecker
Great Tit
Greater Black-backed Gull
Greater Canada Goose
Greater Scaup
Greater Spotted Eagle
Greater White-fronted Goose
Green Sandpiper
Greenish Warbler
Grey Heron
Grey Partridge
Grey Plover
Grey Wagtail
Greylag Goose
Gyrfalcon
Hawfinch
Herring Gull
Hooded Crow
Horned Grebe
Horned Lark
House Sparrow
Hume's Leaf-Warbler
Icterine Warbler
King Eider
Lapland Longspur
Lesser Black-backed Gull
Lesser Redpoll
Lesser Spotted Eagle
Lesser Spotted Woodpecker
Lesser Whitethroat

Alle alle
Tachybaptus ruficollis
Hydrocoloeus minutus
Charadrius dubius
Calidris minuta
Sternula albifrons
Asio otus
Buteo rufinus
Aegithalos caudatus
Clangula hyemalis
Stercorarius longicaudus
Anas platyrhynchos
Poecile palustris
Acrocephalus palustris
Anthus pratensis
Larus melanocephalus

Little Auk
Little Grebe
Little Gull
Little Ringed Plover
Little Stint
Little Tern
Long-eared Owl
Long-legged Buzard
Long-tailed Bushtit
Long-tailed Duck
Long-tailed Jaeger
Mallard
Marsh Tit
Marsh Warbler
Meadow Pipit
Mediterranean Gull



Merganser with chicks.

Falco columbarius
Larus canus
Turdus viscivorus
Circus pygargus
Cygnus olor
Morus bassanus
Accipiter gentilis
Circus cyaneus
Vanellus vanellus
Anas acuta
Corvus corax
Anas clypeata
Oenanthe oenanthe
Emberiza hortulana
Pandion haliaetus
Phylloscopus proregulus
Circus macrourus

Merlin
Mew Gull
Mistle Thrush
Montagu's Harrier
Mute Swan
Northern Gannet
Northern Goshawk
Northern Harrier
Northern Lapwing
Northern Pintail
Northern Raven
Northern Shoveler
Northern Weather
Ortolan Bunting
Osprey
Pallas's Leaf Warbler
Pallid Harrier

Photo: T. W. Johnsen

APPENDIX 3.3



Stercorarius parasiticus
Loxia pytyopsittacus
Falco peregrinus
Recurvirostra avosetta
Pinicola enucleator
Anser brachyrhynchus
Stercorarius pomarinus
Calidris maritima
Alca torda
Loxia curvirostra
Milvus milvus
Calidris canutus
Lanius collurio
Ficedula parva
Branta ruficollis
Mergus serrator

Parasitic Jaeger
Parrot Crossbill
Peregrine Falcon
Pied Avocet
Pine Grosbeak
Pink-footed Goose
Pomarine Jaeger
Purple Sandpiper
Razorbill
Red Crossbill
Red Kite
Red Knot
Red-backed Shrike
Red-breasted Flycatcher
Red-breasted Goose
Red-breasted Merganser

Asio flammeus
Circaetus gallicus
Certhia brachydactyla
Mergellus albellus
Plectrophenax nivalis
Turdus philomelos
Muscicapa striata
Nucifraga caryocatactes
Tringa erythropus
Aquila nipalensis
Columba oenas
Strix aluco
Anthus campestris
Calidris temminckii
Aegolius funereus
Luscinia luscinia
Anthus trivialis
Aythya fuligula
Cygnus columbianus
Carduelis flavirostris
Melanitta fusca
Anthus spinoletta
Rallus aquaticus
Corvus monedula
Circus aeruginosus
Numenius phaeopus
Saxicola rubetra
Ciconia ciconia
Motacilla alba
Haliaeetus albicilla
Cinclus cinclus
Cygnus cygnus
Phylloscopus trochilus
Lullula arborea
Tringa glareola
Phylloscopus sibilatrix
Motacilla flava
Phylloscopus inornatus
Emberiza citrinella
Larus michahellis

Short-eared Owl
Short-toed Snake Eagle
Short-toed Treecreeper
Smew
Snow Bunting
Song Thrush
Spotted Flycatcher
Spotted Nutcracker
Spotted Redshank
Steppe Eagle
Stock Dove
Tawny Owl
Tawny Pipit
Temminck's Stint
Tengmalm's Owl
Thrush Nightingale
Tree Pipit
Tufted Duck
Tundra Swan
Twite
Velvet Scoter
Water Pipit
Water Rail
Western Jackdaw
Western Marsh Harrier
Whimbrel
Whinchat
White Stork
White Wagtail
White-tailed Eagle
White-throated Dipper
Whooper Swan
Willow Warbler
Wood Lark
Wood Sandpiper
Wood Warbler
Yellow Wagtail
Yellow-browed Warbler
Yellowhammer
Yellow-legged Gull



Osprey on the cliff.

Photo: T. W. Johnsen

Falco vespertinus
Podiceps grisegena
Phalaropus lobatus
Cecropis daurica
Gavia stellata
Anthus cervinus
Turdus iliacus
Anthus richardi
Turdus torquatus
Corvus frugilegus
Buteo lagopus
Arenaria interpres
Philomachus pugnax
Riparia riparia
Calidris alba
Sterna sandvicensis
Acrocephalus schoenobaenus

Red-footed Falcon
Red-necked Grebe
Red-necked Phalarope
Red-rumped Swallow
Red-throated Diver
Red-throated Pipit
Redwing
Richard's Pipit
Ring Ouzel
Rook
Rough-legged Buzzard
Ruddy Turnstone
Ruff
Sand Martin
Sanderling
Sandwich Tern
Sedge Warbler

3.4 Dry Grassland Flora at Stevns Klint

Species

Acer pseudoplatanus
Achillea millefolium
ssp. millefolium
Agrimonia eupatoria
Agrimonia procera
Agrostis tenuis
Allium oleraceum
Anthyllis vulneraria
Artemisia campestris ssp. caudata
Botrychium lunaria
Briza media
Bromus hordeaceus ssp. hordeaceus
Calamagrostis epigeios
Campanula persicifolia
Campanula rotundifolia

Common Name

Sycamore Maple

Yarrow
Common Agrimony
Fragrant Agrimony
Common Bent
Field Garlic
Kidney Vetch
Field Mugwort
Moonwort
Quaking-grass
Soft-brome
Wood Small-reed
Peach-leaved Bellflower
Harebell



Cardaminopsis arenosa
Carex flacca
Carex hirta
Carlina vulgaris ssp. *stricta*
Centaurea jacea
Centaurea scabiosa
Centaureum erythraea
Cerastium fontanum ssp. *triviale*
Conium maculatum
Convolvulus arvensis
Crataegus laevigata
Crataegus monogyna
Dactylis glomerata
Daucus carota ssp. *carota*
Diplotaxis muralis
Echium vulgare
Equisetum arvense
Festuca arundinacea
Festuca pratensis
Festuca rubra
Filipendula vulgaris
Galium mollugo
Galium verum
Geum urbanum
Helianthemum nummularium ssp. *nummularium*
Helictotrichon pratense
Hieracium cymosum

Hieracium pilosella
Hieracium umbellatum

Hypericum maculatum
Hypericum perforatum
Hypochoeris radicata
Inula salicina
Juniperus communis
Knautia arvensis
Leontodon autumnalis
Leontodon hispidus
Leucanthemum vulgare
Linaria vulgaris
Linum catharticum
Lotus corniculatus
Medicago lupulina
Ononis repens
Origanum vulgare
Orobancha eliator
Phleum bertolonii
Phleum pratense
Picris hieracioides
Plantago lanceolata
Plantago media
Poa compressa
Poa pratensis ssp. *pratensis*
Polygala vulgaris
Potentilla anserina
Potentilla reptans
Primula elatior
Primula veris
Prunella vulgaris
Prunus avium
Prunus spinosa

Tall Rock-cress
Glaucous Sedge
Hairy Sedge
Carlina Thistle
Brown Knapweed
Greater Knapweed
European Centaury
Common Mouse-ear
Hemlock
Field Bindweed
Midland Hawthorn
Hawthorn
Cock's-foot
Wild Carrot
Annual Wall-rocket
Viper's Bugloss
Field Horsetail
Tall Fescue
Meadow Fescue
Red Fescue
Dropwort
Great Hedge Bedstraw
Lady's Bedstraw
Wood Avens

Common Rock-rose
Meadow Oat-grass
No Common English Name Found
Mouse-ear Hawkweed
No Common English Name Found
Imperforate St. John's-wort
Perforate St. John's-wort
Rough Cat's-ear
Irish Fleabane
Common Juniper
Field Scabious
Autumn Hawkbit
Rough Hawkbit
Ox-eye Daisy
Common Toadflax
Fairy Flax
Common Bird's-foot Trefoil
Black Medick
Common Restharrow
Wild Marjoram
Knapweed Broomrape
Smaller Cats Tail
Timothy
Hawkweed Oxtongue
Ribwort Plantain
Hoary Plantain
Flattened Meadow-grass
Smooth Meadow-grass
Common Milkwort
Silver Weed
Creeping Cinquefoil
Oxlip
Cowslip
Self-heal
Sweet Cherry
Blackthorn

Ranunculus acris
Ranunculus bulbosus
Reseda luteola
Rumex acetosa var. *acetosa*
Scabiosa columbaria
Sedum acre
Senecio jacobaea
Silene nutans
Silene vulgaris ssp. *vulgaris*
Solidago virgaurea
Tanacetum vulgare
Taraxacum sp.
Torilis japonica
Tragopogon pratensis ssp. *minor*
Trifolium arvense
Trifolium campestre

Meadow Buttercup
Bulbous Buttercup
Weld
Common Sorrel
Small Scabious
Biting Stonecrop
Common Ragwort
Nottingham Catchfly
Bladder Campion
Goldenro
Tansy
Common Dandelion
Upright Hedge-parsley
Goat's Beard
Hare's-foot Clover
Hop Trefoil



Pigeon's Scabious before bloom

Trifolium dubium
Trifolium pratense
Tussilago farfara
Veronica arvensis
Veronica chamaedrys
Vicia cracca
Viola hirta

Lesser Trefoil
Red Clover
Colt's-foot
Wall Speedwell
Germander Speedwell
Tufted Vetch
Hairy Violet



3.5 Photographs of Stevns Klint

ID No. Caption	Format (slide/print/video)	Date of photograph	Photographer/director of video	Copyright owner	Contact details of copyright owner	Non-exclusive cession of rights
Stevns Klint 1	jpg	07/2011	Peter Warnamoores	Photographer	GEUS	Yes
Stevns Klint 2	jpg	06/2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 3	jpg	06/2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 4	jpg	06/2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 5	jpg	06/2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 6	jpg	06/2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 7	jpg	06/2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 8	jpg	06/2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 9	jpg	06/2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 10	jpg	06/2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 11	jpg	06/2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 12	jpg	06/2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 13	jpg	07/2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 14	jpg	07/2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 15	jpg	05/2011	Sten Lennart Jakobsen	Photographer	Natural History Museum of Denmark	Yes
Stevns Klint 16	jpg	03/2011	Jan Schulz Adolfsen	Photographer	Natural History Museum of Denmark	Yes

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Appendix 4-6



Appendix 4: Management Plan

Enclosed as a separate volume.

Appendix 5: Erosion Analysis

Enclosed as a separate volume.

Appendix 6: Comparative Analysis

Enclosed as a separate volume.



NOMINATION OF STEVNS KLINT



Nomination of

STEVNS KLINT

for inclusion in the World Heritage List

Appendix 4: Management Plan



Nomination of
STEVNS KLINT

for inclusion in the World Heritage List

Appendix 4: Management Plan





stevns kommune

WORLD HERITAGE CANDIDATE

STEVNSKLINT
STEVNSKLINT
STEVNSKLINT



Stevns Klint Management Plan 2011

Preface

Stevns Klint (Klint = Cliff) is a unique geological locality, which bears witness to an important period in Earth's history. 65 million years ago, a global disaster took place that caused the extinction of more than half of Earth's flora and fauna. Subsequently, life on Earth gradually developed into life as we know it today.

The reason why Stevns Klint is a unique place for experiencing and exploring this drama in Earth's history is not least that there are very significant exposures of geological layers along the 15,5 kilometres of coastline. Such prevalence and visibility cannot be found anywhere else on Earth. This is why Denmark is applying to have Stevns Klint recognised as World Heritage by UNESCO.

In 2009, Stevns Municipality, Østsjælland's Museum and the Heritage Agency of Denmark launched a combined effort to have Stevns Klint inscribed on UNESCO's World Heritage List. Officially, Stevns Klint became a candidate to the World Heritage List at the beginning of 2010, and since then, work has been targeted at documenting Stevns Klint's outstanding universal value and planning the management of the area's values.

This Management Plan is our general management tool, which will help conserve and further Stevns Klint's outstanding universal value. The Management Plan establishes the framework for looking after Stevns Klint in a sustainable manner and in compliance with UNESCO's World Heritage Convention. Thus, we present a number of initiatives that we have already launched or which we are planning to carry out over the coming years.



Our core value in the preparation of the Management Plan has been *sustainability*, which is reflected in the content of the Plan. The objective of the measures we are working with is to protect and conserve the nominated area for future generations, while at the same time make it possible for local residents and visitors to move around the area. Local residents should still be able to live along Stevns Klint, and visitors should be offered better opportunities than currently available to experience the quality of the nominated area. This should take place in a sustainable manner.

The Management Plan has been compiled by Mikkel Schønning Sørensen, DPhil, Development Consultant at Stevns Municipality following collection of data from resource people from Stevns Municipality and Østsjælland's Museum. During the process of preparing the Management Plan, emphasis has been placed on finding solutions that build on professional assessments and which are locally anchored. Thus, the local residents, owners and experts, local advisory organs, interest organisations and other stakeholders have helped phrase values and challenges in relation to Stevns Klint.

This has contributed to raising the quality of the measures that are described in the Management Plan.

With this Management Plan, we have taken a decisive step towards a sustainable management of Stevns Klint and the area along the cliff. However, the work does not end here. Managing the area is an ongoing process, in which we must continually consider changes in the area and ensure that the values and experiences remain intact in the long term. Therefore, the Management Plan will be updated with adjustments and new initiatives.

We have been met with great interest, involvement and support from the local community in our efforts to have Stevns Klint inscribed on UNESCO's World Heritage List.

Poul Arne Nielsen

Mayor

Stevns Municipality

Jens Carl Jørgensen

Chairman of the Board

Østsjælland Museum

Anne Mette Rahbæk

Director

Heritage Agency of Denmark

1 Introduction	8
1.1 Management Plan for Stevns Klint	8
1.2 Agreement with the general public	9
1.3 Administration of and responsibility for Stevns Klint	10
1.3.1 Steering group	11
1.3.2 Project group	11
1.3.3 Primary players	11
1.4 Future organisation	12
1.4.1 Organisation	13
1.4.2 Objective	13
1.4.3 The Board – owner of project Stevns Klint towards World Heritage	13
1.4.4 The Secretariat – handles everyday tasks and answers to the Board	13
1.4.5 Task portfolio	14
1.4.6 Stakeholders	15
1.4.7 Finances	15
2 Stevns Klint – Legislation and Buffer Zones	16
2.1 The nominated area	16
2.1.1 Legislation for the nominated area	16
2.1.2 Property right to the nominated area	18
2.2 Buffer zones	19
2.2.1 Mainland buffer zone	19
2.2.2 Functional buffer zones	20
2.2.3 The maritime buffer zone	23
2.2.4 Property rights in the buffer zones	24
2.3 Legislation	24
3 Vision for Stevns Klint	29
3.1 The Vision for Stevns Klint	29
3.2 Objectives	30
3.2.1 World Heritage	30
3.2.2 Control	30
3.2.3 Local involvement	30
3.2.4 Tourism	30
3.2.5 Presentation and research	31
3.2.6 Traffic infrastructure	31
3.2.7 Activities along Stevns Klint	31
4 Protection and Conservation of Stevns Klint	32
4.1 Protection and conservation of the geological values	32
4.1.1 Current situation	33
4.1.2 Challenges	39
4.1.3 Objectives for protection and conservation	39

4.1.4 Measures	39
5 Nature Preservation	41
5.1 Nature at Stevns Klint	41
5.2 Pasture, scrub and forest	42
5.2.1 Current situation	42
5.2.2 Challenges	46
5.2.3 Objectives for nature preservation	46
5.2.4 Measures	46
6 Research and Dissemination	48
6.1 Research	49
6.1.1 Current situation	49
6.1.2 Challenges	50
6.1.3 Objectives for research	50
6.1.4 Measures	50
6.2 Dissemination	52
6.2.1 Current situation	53
6.2.2 Challenges	55
6.2.3 Objectives for dissemination	55
6.2.4 Measures	55
7 Sustainable Tourism	58
7.1 Visitors' sites and activities	59
7.1.1 Current situation	59
7.1.2 Challenges	65
7.1.3 Objectives for visitors' sites	66
7.1.4 Measures	67
7.2 Service for visitors	69
7.2.1 Current situation	69
7.2.2 Challenges	69
7.2.3 Objectives for tourism	70
7.2.4 Measures	70
8 Infrastructure	72
8.1 Modes of transport	74
8.1.1 Car traffic	72
8.1.2 Bus traffic	72
8.1.3 Train traffic	72
8.1.4 Yachting traffic	72
8.1.5 Bicycle traffic	72
8.1.6 Walking	72

8.2 Infrastructure	75
8.2.1 Current situation	75
8.2.2 Challenges	76
8.2.3 Objectives for infrastructure	77
8.2.4 Measures	78
9 Monitoring and Evaluation	81
9.1 Stevns Klint's Outstanding Universal Value	82
9.2 Nature	83
9.3 Research and dissemination	84
9.4 Tourism	84
9.5 Infrastructure	85
10 Funding	86
10.1 Necessary items	86
10.2 Other items	86
Appendix 1 – Citizen Involvement	87
1.1 Participatory democracy and citizen involvement policy	87
1.2 Plot owner and citizens' meetings	88
1.3 Other involvement of stakeholders	90
1.4 Communication	90



1 Introduction

Stevns Klint is a scenic coastal cliff located about 45 km south of the Danish capital, Copenhagen. The 15,5 km long and up to 41 metres high white coastal cliff offers high quality exposure of the Cretaceous-Tertiary boundary layers marking the severe ecological crisis and mass extinction that put an end to the Mesozoic Era 65.5 million years ago – one of the so-called 'big five' mass extinctions in Earth's history. The Cretaceous-Tertiary mass extinction included the extinction of the dinosaurs and marine reptiles and has played a significant role in studies of the causes of mass extinctions and the effect of extraterrestrial impact on life on Earth.

Stevns Klint is a classical study locality and is arguably the best exposed Cretaceous–Tertiary boundary section in the world with the exceptional boundary layer easily recognisable even to the inexperienced eye. The long, high quality exposure ranks among the most complete and expanded boundary sections, and combined with a very rich and well preserved marine fauna, this provides an excellent possibility for the study of patterns of evolution, extinction and subsequent recovery of a large number of biotic groups across the dramatic boundary.

Criterion (viii): Stevns Klint presents an outstanding example of the Cretaceous–Tertiary boundary that reflects a major event in the history of life on Earth and illustrates one of the largest and most spectacular mass extinctions in Earth's history. The mass extinction at the boundary is particularly spectacular due to its association with an asteroid impact and because it marks the extinction of more than half of all species, including land-living dinosaurs and marine reptiles. The site is therefore a key to the study of the nature of mass extinctions and the tempo and mode of the subsequent recovery, and thus for understanding of key evolutionary problems.

The integrity of Stevns Klint lies in the long, high quality exposure, the complete boundary section and the good preservation of a rich fossil assemblage across the boundary. The exposure has been documented in more than 200 scientific papers since the first works in 1759.

The legal protection of the nominated area and its buffer zone is adequate. The property is well managed and resourced, with this Management Plan in place and resources for its implementation. Key management issues include securing natural erosion, controlling exploitation of natural resources at the cliff, presenting the geological site and its significance, and managing the expected increase in number of visitors to the property.

1.1 Management Plan for Stevns Klint

The Management Plan is an unambiguous and concise account of how Stevns Klint's outstanding universal value is to be safeguarded through sustainable management in compliance with the requirements stated in UNESCO's World Heritage Convention. Thus, the importance of considering the value of Stevns Klint as part of a whole has been stressed, so that apart from the geological values, focus is also on the inclusion of the living nature, cultural history and the overall experience of the cliff. Thereby, the Management Plan aims to ensure a holistic development that takes its starting point in the conservation of the outstanding universal value.

The Management Plan serves as the general management tool used by all who are involved in the work to protect Stevns Klint in a sustainable manner. Thus, the Management Plan sets out a vision, objectives and targets for the work to protect, present and develop Stevns Klint, and the Plan indicates a number of measures in various areas that are of significance to Stevns Klint.

The overall aims of the Management Plan are:
To describe Stevns Klint's geological history and further understanding of its outstanding value.
To improve the possibilities of dissemination, teaching and research about Stevns Klint.
To ensure protection, scientific studies and communication of the values that form the basis for the nomination of the area to be inscribed on the World Heritage List, i.e. the geological layers at Stevns Klint, regardless of whether Stevns Klint is recognised as World Heritage or not.
To describe the different players' tasks in relation to managing, protecting, preserving, developing and presenting Stevns Klint.
To explain the significance of Stevns Klint as UNESCO World Heritage to all residents, users and visitors in the area with a view to increasing interest in and respect for the area.
To present a vision, objectives and targets for Stevns Klint and the surrounding area.
To account for challenges and describe measures that have already been completed or will be initiated to protect the area's integrity.
To provide visitors with a basis that will ensure quality experiences by anchoring and developing tourism on a sustainable foundation.
To create increased coordination and collaboration between the involved players.

The Management Plan will continually be revised in order to ensure well-functioning solutions in the management of Stevns Klint. The first revision of the Management Plan is expected to be carried out in 2016 and from then on, revisions will be carried out every four years. Future revisions of the Management Plan are expected to be initiated after submission of the periodic reports to UNESCO.

1.2 Agreement with the general public

Currently, the area along Stevns Klint is administered on the basis of various legislation and directives, which each indicate restrictions on human use of the area, cf. Chapters 2 and 5. In other words, the management of Stevns Klint already has a strong legal foundation. The future management of the area will also be based on the possibilities contained in legislation. The Management Plan will be incorporated into the coming Stevns Municipal Plan 2013, which is a statutory framework plan for land use in the Municipality. The Management Plan continually refers to legislation, directives, regulations etc. An overview of all Acts and regulations that are applied or will be applied in the management of Stevns Klint is included in Chapter 2.

The Management Plan is not legally binding, but a number of the Plan's elements are legally binding because of legislation. The Management Plan does not replace the statutory planning and management tools, nature or environmental protection programmes or other tools used for the management of Stevns Klint and the surrounding area.

Although the Management Plan is not in itself legally binding, it still has great legitimacy. The Management Plan has been approved both by Stevns Municipality's Municipal Council and by Østsjælland's Museum's Board, and the Plan for Stevns Klint will be maintained regardless of any future status as UNESCO World Heritage.

In the process of elaborating the Management Plan, Stevns Municipality and Østsjælland Museum have also included local citizens, interest organisations, advisory organs and other stakeholders. A number of theme nights have been held for plot owners, and there have been meetings for the general public. The Management Plan has been presented to the public, and citizens' meetings have been held about the Plan with all relevant stakeholders. Thus, citizens and other stakeholders have had the opportunity to comment on the Management Plan.

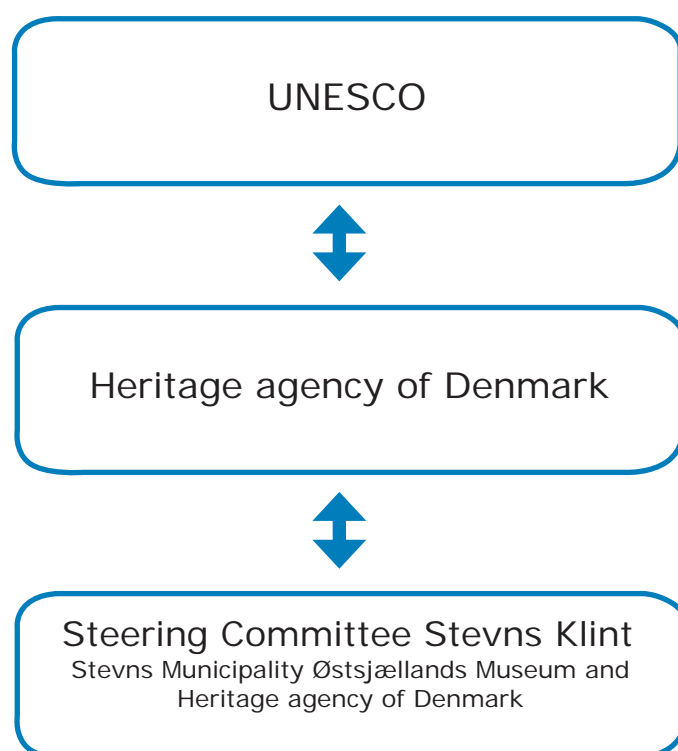
Furthermore, Stevns Municipality and Østsjælland Museum have placed great emphasis on communicating and informing about the work to have Stevns Klint inscribed as UNESCO World Heritage.¹ This has been done via Stevns Municipality's website, both local and national media and a whole string of presentations at meetings with councils, associations etc.

The extensive interest and support from citizens and stakeholders in the work to have Stevns Klint inscribed as World Heritage is an expression of a sense of ownership and responsibility for Stevns Klint and the area's values, which all involved parties acknowledge.

On this basis, the Management Plan may be considered an agreement between authorities, stakeholders and other involved parties. Appendix 1 gives an account of the process of involving citizens, owners, interest organisations, advisory organs and other stakeholders and it contains an overview of all involved stakeholders.

1.3 Administration of and responsibility for Stevns Klint

In Denmark, contact with UNESCO is handled by the Heritage Agency of Denmark. It is the Heritage Agency of Denmark that has proposed Stevns Klint as a candidate for inscription on the World Heritage List; the Heritage Agency will also have the overall responsibility for Stevns Klint as a World Heritage Site in relation to UNESCO and serve as a link to UNESCO.



¹ Stevns Municipality and Østsjælland Museum (ongoing): *Kommunikationsplan for Stevns Klint som UNESCO Verdensarv (Communication Plan for Stevns Klint as UNESCO World Heritage)*, Stevns.

1.3.1 Steering group

The Heritage Agency of Denmark, Stevns Municipality and Østsjællandss Museum collaborate on the inscription of Stevns Klint on UNESCO's World Heritage List. The collaboration is formalised in a Steering Group for Stevns Klint. The Steering Group is composed on the basis of the different members' practical knowledge of and experience with management and control of large projects.

The Steering Group consists of representatives from:	Name	Number of seats
The national administrative authority in relation to UNESCO World Heritage	Heritage Agency of Denmark	1
The local management authority <ul style="list-style-type: none"> • Politicians • Civil servants 	Stevns Municipality	3 2
The professional competence in relation to the site's outstanding universal value <ul style="list-style-type: none"> • Board members • Management 	Østsjællandss Museum	2 1

The Steering Group's current responsibility is:
To work for Stevns Klint's inscription on UNESCO's World Heritage List through the preparation of application and Management Plan.
To set out the general guidelines for Stevns Klint and the surrounding area with a view to ensuring that the nominated area is protected, conserved and presented.
To ensure that stakeholders are involved in connection with the preparation of the Management Plan.
To secure funding for operation and development of the area.

Once the official application and the Management Plan have been submitted to UNESCO, the Steering Group and its field of responsibility will be adjusted in relation to future tasks. Cf. the subsequent future organisation.

1.3.2 Project group

In connection with the preparation of the Management Plan, the Steering Group has appointed an interdisciplinary project group, which has had the task of providing the specialist content. The project group members have particular knowledge in geology, biology, nature preservation, physical planning, dissemination, research, tourism, history, architecture, infrastructure, cartography, health and communication. In addition, the project group has been able to draw on legal assistance.

1.3.3 Primary players

The management of Stevns Klint – i.e. the implementation of the Management Plan – takes place in collaboration between a number of players. The distribution of responsibility and the organisation of management tasks are based on consideration for the players' institutional affiliation and obligations, their ownership along Stevns Klint, and most of all on their specialist competences.

Stevns Municipality and Østsjællandss Museum are the primary motive powers in the realisation of the Management Plan in collaboration with the Heritage Agency of Denmark, the Danish Nature Agency, the

society Selskabet Højeruplund, the association Foreningen Boesdal, Stevns Tourist Association and the Danish Society for Nature Conservation's local branch.

Stevns Municipality

Stevns Municipality is a self-governing, local administrative authority rooted in Danish legislation.² The Municipality handles tasks related to planning, infrastructure, nature preservation, cultural and nature presentation, education, events, and traffic on and along Stevns Klint.

Østsjælland's Museum

Østsjælland's Museum is an independent institution under the Ministry of Culture. The Museum's work includes collecting, registration, conservation, research and dissemination of limestone's geology and local cultural history in accordance with current legislation.³ Østsjælland's Museum's activities along Stevns Klint also include operation of Stevns Museum, Cold War Museum Stevnsfort and Stevns Nature Centre.

The Danish Nature Agency

The Danish Nature Agency is an institution under the Ministry of the Environment, whose purpose it is, among others, to protect, preserve and restore nature, to create nature experiences and present nature to the people and to administer the Ministry of the Environment's forest and nature areas as authority in accordance with the Act on the Protection of Nature. Along Stevns Klint, the Danish Nature Agency's activities are linked to the nature areas Holtug Kridtbrud (chalk quarry), Stevns Reef and Stevns Lighthouse.

Selskabet Højeruplund

In the village of Højerup by Stevns Klint, the society Selskabet Højeruplund owns the area by the memorial park Mindelunden and Højerup Old Church and is responsible for managing, maintaining and presenting the area's history.

Foreningen Boesdal

The association Foreningen Boesdal has an operations agreement with Stevns Municipality for the area Boesdal Kalkbrud (limestone quarry). The association is responsible for managing the area, including nature preservation and holding events.

Stevns Tourist Association

Stevns Tourist Association is an association in Stevns Municipality. The Tourist Association works for sustainable tourism in Stevns and develops and markets quality experiences for visitors. The Association's daily operation is handled by Stevns Tourist Agency.

1.4 Future organisation

With the application for inscription on UNESCO's World Heritage List, the project enters a new stage. During this assessment process, the involved players will continue to work on the implementation of measures and the development of the area. This presupposes not only investments and lasting commitment, but also a strong cross-sectorial organisation and local support.

Below follows a presentation of the future organisation with responsibility for control and development of Stevns Klint. This organisation continues to be a project organisation.

² *Constitution of the Kingdom of Denmark*, Act no. 169 of 5 June 1953 Section 82, The Prime Minister's Office and *Act on Governance of the Municipalities*, Consolidated Act no. 1440 of 1 November 2010, The Ministry of Interior and Health.

³ *The Museum Act*, Consolidated Act no. 1505 of 14 December 2006, the Ministry of Culture.

1.4.1 Organisation

The future organisation is organised as an association, an independent institution, a foundation or similar and consists of a Board and an operating secretariat. It has been considered important that ownership be independent from Stevns Municipality and Østsjællandss Museum so that it is possible to distinguish interests in the nominated area from specific municipal or museum interests. Furthermore, this form of ownership will increase possibilities of seeking external funding from various foundations.

1.4.2 Objective

The most important task is to realise the Management Plan's vision, objectives and targets and to ensure a long-term well-functioning organisation.

The objective is to create a development-orientated organisation, which can constitute the efficient and authoritative forum for development of measures and coordination of tasks in relation to Stevns Klint as a UNESCO World Heritage Site. The organisation is to ensure a competent and dialogue-based balance of all interests in relation to the vision set-up for Stevns Klint, see Chapter 4.

The organisation is to ensure that operational tasks, activities and development projects are anchored in the main stakeholders' organisation and that the local community is involved in decisions of significance to their quality of life / everyday life. The organisation is entitled to make general decisions and, if necessary, operate with short deadlines.

1.4.3 The Board – owner of project Stevns Klint towards World Heritage

The Board is charged with making overall decisions and phrasing concrete tasks for the operating unit to realise. The provisional task portfolio is presented in Chapter 1.4.5.

The Board is a further development of the current Steering Group. The most significant differences are that the Danish Nature Agency will be represented on the Board and that the Heritage Agency of Denmark will leave the Board; however, close communication will be maintained with the Heritage Agency of Denmark. Finally, the number of representatives will be reduced. This organisation composition is to ensure flexibility and efficiency in relation to the pending tasks. The Head of Secretariat for the operating unit will be Secretary to the Board.

The Board consists of one representative each from:	Function
Stevns Municipality <ul style="list-style-type: none">• Politicians	Local management authority
Østsjællandss Museum <ul style="list-style-type: none">• Board members	Professional competence in relation to the site's outstanding universal value
Possibly a representative for plot owners <ul style="list-style-type: none">• Plot owners	Handle the interests of plot owners
Possibly the Danish Nature Agency <ul style="list-style-type: none">• Civil servant	National nature management authority

1.4.4 The Secretariat – handles everyday tasks and answers to the Board

The Secretariat is the operative organ, which is to ensure that the Board's decisions are implemented and that relevant stakeholders are involved in relation to the impact on their work. The Secretariat is to be outgoing in relation to the tasks, enter into agreements with other operators, strive to procure funding and handle representative tasks.

The Secretariat is anchored physically in Stevns Municipality and Østsjælland Museum.

The Secretariat consists of:	Competence
Head of Secretariat (part-time)	In-depth knowledge of Stevns Klint's outstanding universal value Project management experience Expertise in fundraising, incl. experience with national foundations
AC project coordinator	Solid management experience Solid project management experience

1.4.5 Task portfolio

The objective of the organisation is specified in a number of tasks, which are to be carried out on the basis of a coordinated effort between the involved players.

The task portfolio below reflects the vision, objectives and targets of the Management Plan. They consider the interests of both main stakeholders and the local community within the framework of the overall vision.

Future responsibility of the Steering Group	Content. The organisation is to:
Protect and conserve Stevns Klint	Safeguard Stevns Klint's outstanding universal value – i.e. the basis for recognition as UNESCO World Heritage.
Contact to UNESCO via the Heritage Agency of Denmark	Ensure communication in relation to UNESCO in connection with assessment, periodic reports etc. Procure up-to-date knowledge about UNESCO's guidelines etc.
Management	Handle implementation of Management Plan, incl. monitoring. Carry out qualitative and quantitative evaluations of objectives in relation to the World Heritage project. Lay down general guidelines for activities along Stevns Klint. Evaluate and possibly update the Management Plan, incl. monitoring of the area.
Finances and organisation	Secure funding for operation and development of the area. Manage funds for new measures.
Research and dissemination	Promote research in geology, nature and cultural history. Ensure dissemination of the cliff's outstanding universal value.
Local anchoring	Ensure citizen involvement in relation to protection, nature preservation and presentation as well as tourism and recreational development.

Communication	Establish a welcome centre, incl. end user communication.
	Carry out strategic communication.
Branding	Ensure targeted marketing of Stevns Klint as a site of interest.
Recreational use / tourism	Ensure sustainability in recreational activities and tourism, cf. UNESCO's guidelines and local interests.
	Promote tourism-related interests, incl. extension of facilities, infrastructure etc.
	Network and further develop collaboration with other World Heritage Sites in Denmark.

1.4.6 Stakeholders

The stakeholders have been identified in connection with the application process. The group of stakeholders is large and diverse. The nominated area is mainly private property, and 98% of the Outstanding Universal Value belongs to the Gjorslev Estate.

The organisation that deals with Stevns Klint as World Heritage is to ensure that the interests of the stakeholders are handled professionally. Experience shows that stakeholders must be considered as individual stakeholders, who must be contacted directly, as has been the case during the application process. For instance, plot owners must be contacted via plot owners' meetings, and raw material producers must be contacted through bilateral meetings.

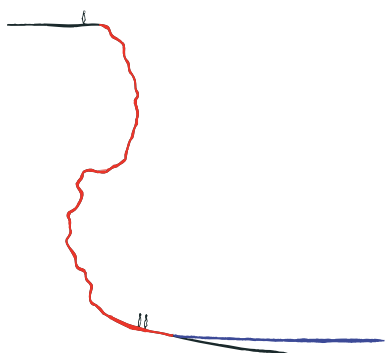
Based on the experience gained from the application process, it is clear that the organisation has to be actively extrovert, outgoing and receptive in relation to the stakeholders. Emphasis is on dialogue and collaboration, so that the respective stakeholders' practical knowledge and experience can be utilised as best as possible in the work to protect, conserve, develop and present Stevns Klint.

1.4.7 Finances

There will be many tasks in relation to Stevns Klint in the first years, and then the amount will drop – regardless of whether or not Stevns Klint is inscribed on UNESCO's World Heritage List. The organisation is expected to have a limited life, e.g. five years. After that, the Board will decide on a possible organisational change.

The Municipal Council of Stevns Municipality has allocated 3 million kroner in the budget for the years 2012 to 2015. The money is earmarked for the tasks that are to be carried out pursuant to the Management Plan and for salaries in the coming organisation. It is expected that considerable external financing will be procured via fundraising conducted by the operative unit.

2 Stevns Klint – Legislation and Buffer Zones



Sketch of cliff profile

Stevns Klint is located on the peninsula of Stevns – just 70 kilometres south of Denmark’s capital, Copenhagen. This is a 15,5 km long coastal cliff, which constitutes a dramatic boundary between the flat moraine landscape and the Baltic Sea with a level difference of up to 41 metres.

As a geological locality, Stevns Klint is unique on Earth, and because of this quality, a special responsibility rests with the primary players, collaborators and the local community to safeguard and look after the geological values. In order for this to succeed through sustainable and well-functioning protection and conservation of Stevns Klint, it is of vital importance that the nominated area and the appertaining values at Stevns Klint be unambiguously delimited and defined.¹

In this chapter, the nominated area is defined. Furthermore, an account is given of the adjacent buffer zones, which help create further protection of the area and whose cultural and natural values are an important contribution to the combined presentation of Stevns Klint. The chapter distinguishes between mainland, functional and maritime buffer zones.

2.1 The nominated area

The nominated area of outstanding universal value consists of Stevns Klint and four different localities on or close to the coastal cliff.

The nominated area consists of:
The cliff that exists at any given time along the entire 17 km stretch from Rødvig to Bøgeskov. Along this stretch, waves from the Baltic Sea continually cause erosion and new fresh exposures in Stevns Klint. Only a small opening – of 157 metres – by the chalk quarry Sigerslev Kridtbrud is not a part of the nominated area. The nominated area is defined from the cliff edge to 0 m above sea level according to <i>Dansk Vertikal Reference</i> 1990, which is prepared by the Danish Map and Land Register Agency
A south-facing cliff profile by the open air stage in the limestone quarry Boesdal Kalkbrud. The profile’s geological layer series is a particularly good example of a symmetrical bank form and it therefore contributes to support the integrity of Stevns Klint.
The underground passages in Cold War Museum Stevnsfort. The geological layers can be seen in three dimensions in the approx. 1.6 km passage system, contributing to Stevns Klint’s integrity.
The chalk quarry Holtug Kridtbrud. The abandoned quarry contains a visible version of the bryozoan banks that is particularly low in bryozoans, which complements Stevns Klint’s integrity.
The limestone banks on the seafloor off Stevns Klint. The limestone banks’ outline contributes to the nominated area’s integrity.

¹ UNESCO (2008): *Operational Guidelines for the Implementation of the World Heritage Convention*, World Heritage Centre, p 25-27.

Map of the nominated area and buffer zones

Stevns Klint, 8 July 2011



Geological profiles in Holtug Kridtbrud.



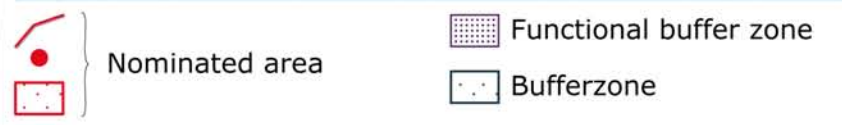
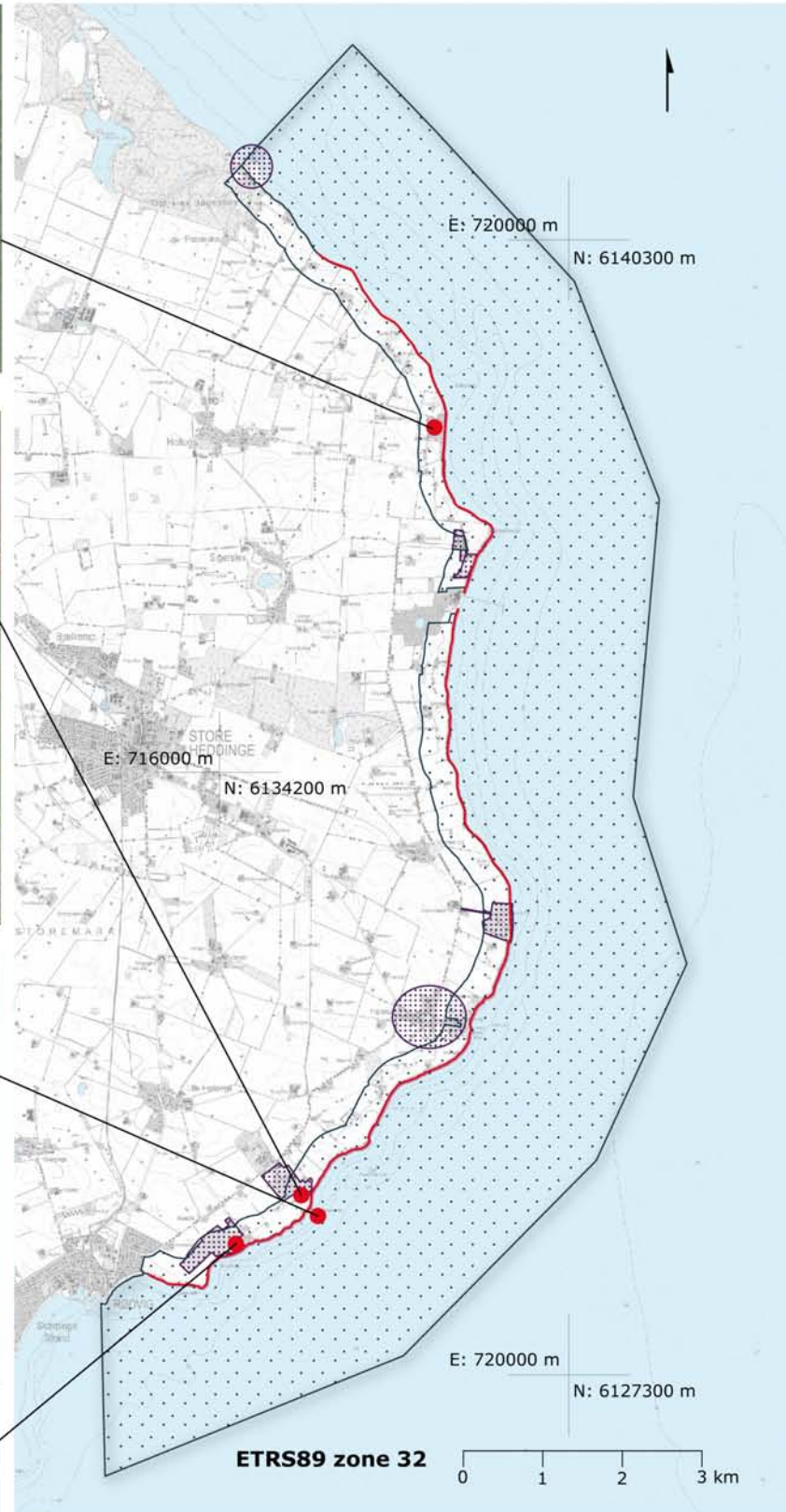
Tunnels in Cold War Fortress Stevnsfort.



Limestone mounds on seafloor.



Geological profile at Boesdal Kalkbrud.



2.1.1 Legislation for the nominated area

Stevns Klint has been designated an Area of National Geological Interest², which means that the area is of fundamental importance to the understanding of Denmark's geological development. The Planning Act stipulates that Areas of National Geological Interest must be secured and conserved, which is ensured purely administratively via Stevns Municipal Plan.³

Furthermore, the European Association for the Conservation of the Geological Heritage, ProGeo, has designated Stevns Klint a GeoSite. This means that Stevns Klint is included in a network of particularly important geological areas in Europe that are of scientific significance. In terms of protection, GeoSites are ranked alongside Areas of National Geological Interest.

The entire nominated area is covered by the Act on the Protection of Nature, Section 15 on the protection of coastal areas. This Act prohibits changes to the condition of beaches or other coastal areas. The Section entails, among other things, that it is prohibited to alter the terrain, remove raw materials by digging or add soil, plants, trees or bushes. Section 22 of the Act on the Protection of Nature ensures public access, so that the stretch of coast is open to traffic on foot, brief occupancy and swimming – at the individual's own risk.⁴ Chapter 2.2.1 includes further details about the Act, which also applies to mainland buffer zones.

The nominated area along Stevns Klint is also covered by the Act on Coastal Protection.⁵ The Act ensures that due consideration is given to the conservation of the coastal landscape and the unhindered development of nature prior to the establishment of any coastal protection. Chapter 5.1 deals with coastal protection.

The nominated localities of Boesdal Kalkbrud and Cold War Museum Stevnsfort are managed according to the Planning Act's Part 5 on Local Planning.⁶ The areas' local plans include guidelines for the use of the areas and concrete preservation plans with a view to nature protection. Chapter 2.2.2 gives a brief account of current local plans for Boesdal Kalkbrud and Cold War Museum Stevnsfort, respectively, considering that the areas constitute functional buffer zones.

Holtug Kridtbrud and the limestone banks off Stevns Klint are part of the European Natura 2000 nature protection network and are therefore managed according to the applicable Directive. The Directive, which has been implemented in Danish legislation via the Act on Environmental Objectives, aims to conserve endangered habitats as well as wild fauna and flora.⁷ The limestone banks off Stevns Klint are covered by bans on suction, digging and boulder fishing from the seafloor.⁸ A brief description of the Natura 2000 area off Stevns Klint is given in Chapter 2.2.3. This area forms a maritime buffer zone to the nominated area.

2.1.2 Property right to the nominated area

In general, there are two forms of ownership in the nominated area: public and private.

2 The Danish Conservation Agency (1984): *Fredningsplanlægning og geologi. Nationale geologiske interesseområder (Conservation Planning and Geology. Sites of National Geological Interest)*, Ministry of the Environment, Copenhagen.

3 *Planning Act*, Consolidated Act no. 937 of 24 September 2009, Section 11a, subsection 1, item 16, Ministry of the Environment, and Stevns Municipality (2009): *Stevns Municipal Plan 09*, Stevns, pp. 191-193. Also see the Danish Nature Agency (2011) *Oversigt over statslige interesser i kommuneplanlægningen 2013* (Overview of Governmental Interests in Municipal Planning 2013), Ministry of the Environment, Copenhagen.

4 *Act on the Protection of Nature*, Consolidated Act no. 933 of 24 September 2009, Ministry of the Environment.

5 *Act on Coastal Protection*, Consolidated Act no. 267 of 11 March 2009 Section 1, Ministry of Transport.

6 *Planning Act*, Consolidated Act no. 937 of 24 September 2009, Ministry of the Environment. Stevns Municipality (2007): *Local Plan 47 for Boesdal Kalkbrud*, Dept. of Technology and Environment. See <http://www.stevnskom.dk/Lokalplaner/47.pdf>. Stevns Municipality (2007): *Local Plan 77a, Cold War Museum Stevnsfort*, Dept. of Technology and Environment. See <http://www.stevns.dk/lib/file.aspx?fileID=1055&target=blank>.

7 *Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats of Wild Fauna and Flora*, The European Union. *Act on Environmental Objectives*, Consolidated Act no. 932 of 24 September 2009, Ministry of the Environment.

8 *Executive Order on Prohibition of Exploration and Extraction of Raw Materials from the Seafloor in EEC Bird Protection Areas and in Ramsar Areas*, Executive Order no. 984 of 5 December 1994, the Ministry of the Environment.

The nominated area	Property right
Stevns Klint, 2.3% public property	Stevns Municipality The State
Stevns Klint, 97.7% private property	Private plot owners – 95% owned by the Gjorslev Estate
Holtug Kridtbrud	The State
Limestone banks off Stevns Klint	The State
Cliff profile at Boesdal Kalkbrud	Stevns Municipality
Underground passages in Cold War Museum Stevnsfort	Stevns Municipality

Certain localities along Stevns Klint, which serve as access routes to the cliff, are all owned by public institutions or by private associations, whose purpose it is to present and manage the area's natural and culture-historical heritage.

Locality	Owner	Responsible for operation
Boesdal Kridtbrud	Stevns Municipality	The association Foreningen Boesdal
Stevnsfort	Stevns Municipality	Østsjælland Museum
Højeruplund	The society Selskabet Højeruplund	The society Selskabet Højeruplund
	Østsjælland Museum	Østsjælland Museum
Stevns Lighthouse	The State	Stevns Municipality
	Stevns Municipality	Stevns Municipality
Mandehoved/Flagbanken	Stevns Municipality	Østsjælland Museum
Holtug Kridtbrud	The State	Østsjælland Museum

2.2 Buffer zones

The purpose of operating with buffer zones around the nominated area is primarily to ensure an efficient protection of the outstanding universal value.

The buffer zones along Stevns Klint on the mainland are established on the basis of the Act on the Protection of Nature Section 15 on the protection of coastal areas, and at sea, they are based on the EU protected Nature 2000 area. These provisions lay down well-defined limits for the area's use and development possibilities, and as such, they serve as extended, protective zones in relation to the nominated area.

Further to the buffer zones on land and at sea by Stevns Klint, a number of functional buffer zones have been established. The functional buffer zones are to contribute further to the protection of the nominated area through efficient planning in relation to visitors and control of human activities in the zones.

2.2.1 Mainland buffer zone

The mainland buffer zone follows an area managed under the Act on the Protection of Nature's Section 15 on the protection of coastal areas. As will be mentioned in Chapter 2.3, this legislation prohibits alterations to the condition of beaches or other areas located between the beach and the beach protection line.

Along the entire length of Stevns Klint from Rødvig to Bøgeskov, an area located between the beach and the beach protection line 300 metres inland has been established by the Ministry of the Environment as being covered by the legal provision. This buffer zone is dynamic, as the beach protection line is established according to the existing beach at any given time. This means that the buffer zone is adjusted proportionally with new erosions of Stevns Klint. Today, the buffer zone's total area covers approx. 500 hectares.

The concrete prohibitions, which Section 15 of the Act on the Protection of Nature implies for the mainland buffer zones along Stevns Klint, are summarised below.

According to the Act on the Protection of Nature Section 15 it is prohibited to:
Erect fences, masts, stands, signs etc.
Place caravans, portable cabins or similar.
Carry out partitioning, registration or area transfer whereby boundaries are established.
Erect new buildings or alter or expand existing buildings.
Alter the terrain by moving, removing or adding e.g. soil or stones.
Plant trees, bushes etc.
Build terraces or stairs.
Deposit garden waste and similar.

There are a few exceptions to the above, but none of these is of relevance to the protection, conservation or presentation of Stevns Klint. Special regulations apply to agriculture, which means that subject to approval, buildings that are necessary for commercial purposes may be erected, and buildings may be removed. However, it should be stressed that dispensation from the legal provisions are only given in very special cases, as the provisions have been strictly adhered to since they entered into force in 1937. Today, the Danish Nature Agency's Roskilde branch administers Section 15 of the Act on the Protection of Nature.

It is assessed that a buffer zone that reaches 300 metres inland and which is managed on the basis of Section 15 of the Act on the Protection of Nature helps maintain the integrity of the nominated area and safeguard the area's spatial conditions and the visitors' visual experience.

2.2.2 Functional buffer zones

The functional buffer zones complement the mainland buffer zone and their purpose is to serve as further protection for the nominated area, considering that these buffer zones make it possible to plan for visitors and control human activities based on the provisions of the Planning Act.⁹ In other words, the functional buffer zones are of significant functional importance to the protection of the nominated area.

The functional buffer zones are: Boesdal Kridtbrud, Cold War Museum Stevnsfort, Højerup, Stevns Lighthouse (Stevns Fyr), Mandehoved/Flagbanken and Bøgeskov. These buffer zones have been chosen because they are central to the experience of Stevns Klint. Some of these localities are partly or completely located outside the buffer zone used for management in accordance with the Act on the Protection of Nature's Section 15 on the protection of coastal areas. Further to the above localities, Holtug Kridtbrud is also a central visitors' site.

⁹ *Planning Act*, Consolidated Act no. 937 of 24 September 2009, Ministry of the Environment.

Boesdal Kalkbrud

The limestone quarry Boesdal Kalkbrud is located at the southern part of Stevns Klint, and a south-facing cliff profile forms part of the nominated area. The area is an abandoned limestone quarry, which today serves as a recreational area. A local plan is in force for this area, which includes a nature preservation plan, among other things.¹⁰ The area has an efficient footpath system, which makes it possible to experience Stevns Klint both from the cliff edge and from the beach. The area is easily accessible, has parking and toilet facilities and is very suitable for outdoor events.

Cold War Museum Stevnsfort

Cold War Museum Stevnsfort is a modern museum located in a former military facility on the southern stretch of Stevns Klint. The underground passages form part of the nominated area. By the Museum, Stevns Klint can also be experienced from the cliff edge. A local plan with appertaining preservation plan is in force for Cold War Museum Stevnsfort.¹¹ The area includes a large parking area, a visitors' centre with school service and guided tours, outdoor exhibition areas and footpath systems along Stevns Klint.

Højerup

Højerup is a village that is inextricably connected to the history of Stevns Klint. More than anything, Højerup is the central place from which to experience Stevns Klint. Højerup offers visitors the opportunity of experiencing Stevns Klint both from the cliff edge and from the beach. The village also has several interesting culture-historical buildings and recreational facilities as well as Stevns Museum. Historically, Højerup is the classical visitors' site, and today, it is the primary entrance to Stevns Klint.



Højerup

Stevns Lighthouse, Stevns Fyr

Stevns Lighthouse (Stevns Fyr) covers the areas Stevns Lighthouse and Squadron 543. The area contributes to the overall experience of Stevns Klint. The view from the cliff edge and the good conditions for disabled people in the area mean that walking-impaired people and wheelchair users are able to get right to the edge of Stevns Klint. The two lighthouses and the lighthouse keeper's house are listed and worth visiting. The area is covered by a local plan with appertaining nature preservation plan.¹²

¹⁰ Stevns Municipality (2007): *Local Plan 47 for Boesdal Kalkbrud*, Dept. of Technology & Environment. See <http://www.stevnskom.dk/Lokalplaner/47.pdf>.

¹¹ Stevns Municipality (2007): *Local Plan 77a, Cold War Museum Stevnsfort*, Dept. of Technology & Environment. See <http://www.stevns.dk/lib/file.aspx?fileID=1055&target=blank>.

¹² Stevns Municipality (2006): *Local Plan 73, Stevns Lighthouse*, Dept. of Technology & Environment. See <http://www.stevnskom.dk/Lokalplaner/Lok73E.pdf>

Mandehoved/Flagbanken

Mandehoved and Flagbanken are located about 40 metres above sea level, which makes them some of the highest places along Stevns Klint, and the area offers views from the cliff edge. The area also offers good conditions for visitors and it is an important locality because of the view and the teaching and presentation activities.

Bøgeskov

Bøgeskov is found about 100 metres to the north of Stevns Klint. The area includes a small harbour and a small car park, which is served by public transport (bus). The location is good for visitors who wish to experience Stevns Klint from the beach or from the seaward side. A clearly marked footpath runs from Bøgeskov on the beach along the northernmost part of Stevns Klint. No local plan has been drawn up for Bøgeskov, and Stevns Municipality assesses that there is no immediate need for this, as the area currently works well for visitors. A local plan for the area may be necessary in future to facilitate control and adjustment of the use of the area.

Holtug Kridtbrud

The chalk quarry Holtug Kridtbrud forms part of the nominated area. It contributes to the experience of Stevns Klint, and the area around the abandoned quarry's car park has an important function in relation to receiving and controlling visitors.

Information	Location	Geographical position		Extension (approx.)
Stevns Klint	Stevns Klint – from Bøgeskov to Rødvig	E: 717.107	N: 6.140.172	15.5 km
		E: 715.164	N: 6.128.461	41.1 hectares
Cold War Museum Stevnsfort	Underground passages at Stevns Klint	E: 716.984	N: 6.129.413	1.6 km 8.300 m ²
Boesdal Kalkbrud	Cliff profile at Boesdal Kalkbrud	E: 716.246	N: 6128.821	77 m 375 m ²
Holtug Kridtbrud	Holtug Kridtbrud	E: 718.521	N: 6.138.085	4.6 hectares
Limestone banks on seafloor	Off Stevns Klint by Cold War Museum Stevnsfort	E: 716.930	N: 6.129.034	9.15 hectares
Mainland buffer zone	300-metre zone between the beach and the beach protection line from Bøgeskov to Rødvig	E: 716.044	N: 6.140.960	500 hectares, incl. functional buffer zones
		E: 715.133	N: 6.128.656	

Information	Location	Geographical position		Extension (approx.)
Maritime buffer zone	Natura 2000 area between the coastline and approx. 2 km out into the Baltic Sea from Bøgeskov to Rødvig	E: 717.526	N: 6.142.539	3.700 hectares
		E: 714.690	N: 6.126.142	
Functional buffer zones	Bøgeskov	E: 716.373	N: 6.141.139	
	Højerup	E: 718.413	N: 6.131.389	
	Cold War Museum Stevnsholm	E: 716.704	N: 6.129.499	
	Boesdal Kalkbrud	E: 716.022	N: 6.128.812	18 hectares

2.2.3 The maritime buffer zone

The maritime buffer zone follows the international Natura 2000 area off Stevns Klint. Natura 2000 is a collective name for protected nature areas selected and managed in accordance with the European Union's nature protection directives, which include the Birds Directive and the Habitat Directive. The objective for the areas is to conserve and protect habitats and wild fauna and flora species that are rare, endangered or characteristic of countries within the European Union.¹³

The maritime buffer zone covers the entire stretch from Rødvig to Bøgeskov between the coastline and approx. 2 km out into the Baltic Sea. The Natura 2000 area off Stevns Klint was selected by the Ministry of the Environment in 1998 based on Stevns Reef and sea-covered sandbars. A disembarkation pier by the chalk quarry Sigerslev Kridtbrud and a transformer station off Bøgeskov Harbour, which are located within the Natura 2000 area, are not covered by the provisions of the Directives. The Natura 2000 area has a total area of approx. 3,700 hectares.



The maritime buffer zone

The area is managed by the Ministry of the Environment, and according to legislation, other authorities are under obligation to base their area operation, nature management or other practice of their respective powers on the plan for the Natura 2000 area.

¹³ Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats of Wild Fauna and Flora, The European Union. The Directive has been implemented in Danish legislation via the *Act on Environmental Objectives*, Consolidated Act no. 932 of 24 September 2009, Ministry of the Environment.

The area's status as part of the international Natura 2000 nature protection network binds the Ministry of the Environment to make efforts to ensure that Stevns Reef maintains a good water quality, diverse underwater vegetation and remains a good habitat for the species of bottom fauna and fish that are common to the area. Pursuant to applicable national legislation, the area is covered by a ban on the use of trawl¹⁴ and suction, digging and boulder fishing.¹⁵

In addition, the police district of Central and West Zealand has established regulations for sailing with motorboats and surfing off the coast by Stevns Klint. This implies, among other things, that sailing must take place in a way that avoids noise that might be of nuisance to others. Sailing should also take place in a way that does not disregard fauna and nature protection considerations.¹⁶

Considering the protective measures and restrictions that are associated with the Natura 2000 area off the coast along Stevns Klint, it is assessed that the maritime buffer zone helps protect and conserve the limestone banks off Stevns Klint as well as the actual cliff.

2.2.4 Property rights in the buffer zones

The property rights in the buffer zones belong to a number of players.

Property rights in the buffer zones
The State owns the waters off Stevns Klint as well as areas by Stevns Lighthouse (Stevns Fyr) and Mandehoved.
Stevns Municipality owns Boesdal Kalkbrud, an area that contains Cold War Museum Stevnsfort as well as pastures between the Museum and the cliff edge, Squadron 543 by Stevns Lighthouse (Stevns Fyr), Stevns Nature Centre in Mandehoved and Flagbanken.
The Gjorslev Estate owns the un-registered area by Bøgeskov. The Estate also holds registered rights for extraction of chalk and limestone along Stevns Klint, see Chapter 4.1.1.
The society Selskabet Højeruplund owns the area around Højerup, including the Memorial Park and Højerup Old Church.
Østsjælland's Museum owns Stevns Museum in Højerup and pastures to the south of the Museum.
Other areas in the buffer zones are owned by businesses and private plot owners.



Stevns Klint

¹⁴ Executive Order on Trawling and Other Seine Fishing, Executive Order no. 18 of 14 January 1993 Section 6 item 15 and Section 19, Ministry of Food, Agriculture and Fisheries.

¹⁵ Executive Order on Prohibition of Exploration and Extraction of Raw Materials from the Seafloor in EU Bird Protection Areas and in Ramsar Areas, Executive Order no. 984 of 5 December 1994, Ministry of the Environment.

¹⁶ Executive Order on Prohibition of Exploration and Extraction of Raw Materials from the Seafloor in EU Bird Protection Areas and in Ramsar Areas, Executive Order no. 984 of 5 December 1994, Ministry of the Environment.

2.3 Legislation

The nominated area and the buffer zones are covered by a number of Acts, which each sets out the framework for human activity. The applicable regulations for Stevns Klint are described in detail in the chapters of the Management Plan where this is relevant. The table below briefly describes the legislative basis for the management of Stevns Klint and the buffer zones.

Legislation	Description
<p>Planning Act</p> <p>Consolidated Act no. 937 of 24 September 2009</p>	<p>The Planning Act is to ensure that the overall planning combines social interests in the use of the area and contributes to protecting Denmark's nature and environment so that social development can take place on a sustainable basis with respect for human living conditions and the preservation of fauna and flora. The Act is the basic planning tool for Stevns Municipality.</p> <p>Part 2a on planning in coastal areas ensures that the areas are kept free of buildings and facilities that are not dependent on being close to the coast.</p> <p>Part 4 on municipal planning ensures that a main structure and guidelines are established for municipal land use along with a framework for the contents of local plans.</p> <p>Section 11 a, subsection 1, item 16 is to secure the safeguarding of geological assets worthy of conservation, including the location of areas with special geological value. In comments to the Act, it is stated that valuable geological landscape features, their mutual transitions and correlations are to be safeguarded and that valuable geological coast profiles are to be conserved.</p> <p>Part 5 on local planning makes it possible to outline detailed plans for land use in a limited area. As for the buffer zone, local plans have been drawn up for Boesdal Kalkbrud, Cold War Museum Stevnsfort and Stevns Lighthouse. A local plan for Højerup is planned for 2012.</p> <p>Part 7 on rural zone administration outlines a number of restrictions about parcelling out, new construction and alterations of existing buildings in rural zones and coastal zones.</p>

Legislation	Description
<p>Act on the Protection of Nature</p> <p>Consolidated Act no. 933 of 24 September 2009</p>	<p>The Consolidated Act is to contribute to safeguarding Denmark's nature and environment so that social development can take place on a sustainable basis with respect for human living conditions and for the conservation of fauna and flora.</p> <p>Section 3 of the Act on the Protection of Nature protects lakes, streams, heaths, bogs, salt marshes, swamps, water meadows, pastures etc. along Stevns Klint against alterations of their condition.</p> <p>Section 15 of the Act protects against alterations in the coastal areas. The area between the beach and the beach protection line 300 metres inland helps ensure that the areas around Stevns Klint are kept clear of interventions that would change their current state and use.</p> <p>Section 22 ensures public access, so that the coast is open to traffic on foot, brief occupancy on the beach and swimming – at the individual's own risk.</p> <p>Section 29a protects a number of rare or endangered animal species against deliberate disturbance with detrimental effect to the species or the population. The Section also prescribes that breeding and resting areas for the different species must not be damaged or destroyed.</p>
<p>Act on Coastal Protection</p> <p>Consolidated Act no. 267 of 11 March 2009</p>	<p>One of the objectives of coastal protection is to protect property against erosion from the sea. This objective is handled via a balancing of the need for coastal protection, conservation of the coastal landscape and restoration and the free development of nature.</p> <p>Weighty arguments are needed if coastal protection facilities are to be established along the coast off Stevns Klint, which is currently untouched by such facilities. The more valuable a coastline is considered to be in terms of coastal dynamics, geology, landscape and biology, the greater the requirements on the justification for establishing such a facility.</p>
<p>The European Union's Habitat Directive</p> <p>Council Directive 92/43/EEC of 21 May 1992</p>	<p>The objective of the Directive is to ensure conservation of habitats and wild fauna and flora. The Directive binds Denmark to safeguard or restore a number of rare, endangered or characteristic habitats and species. The Natura 2000 areas along Stevns Klint and a number of species are covered by the Directive.</p>
<p>Act on Environmental Objectives</p> <p>Consolidated Act no. 932 of 24 September 2009</p>	<p>One of the objectives of the Act is to establish a framework for planning within the international nature protection areas.</p> <p>The Act implements the European Union's Directive 92/43/EEC of 21 May 1992 on the conservation of habitats and wild fauna and flora in Danish legislation.</p> <p>Holtug Kridtbrud, the waters off Stevns Klint and a number of fauna and flora species are covered by the Act and the Directive.</p>

Legislation	Description
<p>The European Union's Birds Directive</p> <p>Council Directive 79/409/EEC of 2 April 1979 on the protection of wild birds</p>	<p>The Directive aims to conserve, manage and regulate all of the wild bird species that naturally stay within the member states' European territory – including their eggs, nests and habitats – and to regulate the exploitation of these species.</p>
<p>Executive Order on protection of certain animal and plant species etc., capturing and trading game and caring for injured game</p> <p>Executive Order no. 901 of 11 July 2007</p>	<p>The objective of the Executive Order is to conserve and protect animal and plant species.</p>
<p>Act on Fisheries</p> <p>Consolidated Act no. 978 of 26 September 2008</p> <p>Executive Order no. 18 of 14 January 1993</p>	<p>The Act on Fisheries serves the purpose of ensuring both protection and support of living resources in salt and freshwater and of protecting other fauna and flora as well as securing a sustainable foundation for commercial fishing.</p> <p>The Executive Order on trawling and other seine fishing within Danish fishing territory with any kind of trawl or seine fishing tool.</p> <p>Section 6 item 15 prohibits otter trawling in the area off Stevns Klint.</p> <p>Section 19 prohibits pelagic trawling in the area off Stevns Klint.</p>
<p>Executive Order on Law Enforcement</p> <p>Consolidated Act no. 511 of 20 June 2005</p> <p>Regulations on sailing with motorboats and surfing off the coast of the Central and West Zealand Police District</p>	<p>The Executive Order's Section 14 subsection 2 grants the Police the authority to establish regulations for sailing with motorboats and surfing off the coast.</p> <p>The regulations established by the Central and West Zealand Police District – including the waters off Stevns Klint – prescribe, among other things, that all sailing must take place so that noise that may be a nuisance to others is avoided. Sailing should also take place in a way that does not disregard fauna and nature protection considerations.</p>

Legislation	Description
<p>The Museum Act</p> <p>Consolidated Act no. 1505 of 14 December 2006</p>	<p>The objective of the Act is to further the museums' activity and collaboration with a view to safeguarding Denmark's cultural and natural heritage and access to and knowledge about this and its interaction with the surrounding world.</p> <p>Section 31 of the Act stipulates that any geological object, botanical or zoological object of a fossil or subfossil nature and meteorites is fossil trove (<i>danekræ</i>) if the object is of unique scientific or exhibitional value.</p> <p>Østsjællandss Museum handles collecting, registration, conservation, research and dissemination about limestone geology and cultural history in accordance with the Museum Act.</p>
<p>Act on Raw Materials</p> <p>Consolidated Act no. 950 of 24 September 2009</p> <p>Executive Order no. 984 of 5 December 1994</p>	<p>The objective of the Raw Materials Act is to ensure that the exploitation of raw material deposits on land and at sea is carried out as part of a sustainable development.</p> <p>The Executive Order includes a ban on exploration and extraction of raw materials from the seafloor within EU bird protection areas and in Ramsar areas. The Natura 2000 area off Stevns Klint is covered by a ban on suction, digging and boulder fishing.</p>
<p>The Constitution of the Kingdom of Denmark</p> <p>Act no. 169 of 5 June 1953</p>	<p>Section 73 of the Constitution deals with both the sanctity of property rights and expropriation. The subsection on expropriation and the right to compensation may become relevant in relation to the Gjorslev Estate's registered rights to quarry inside the buffer zone. See Chapter 2.2.4</p> <p>Section 82 of the Constitution safeguards municipal local government. This is of significance to Stevns Municipality's operational and development tasks inside the buffer zones.</p>

3 Vision for Stevns Klint

The vision work is a very important focal point in the effort to produce an efficient Management Plan. The vision for Stevns Klint originates from the World Heritage Convention and a number of formal discussions among the involved stakeholders. The Steering Group and staff at Stevns Municipality, Østsjælland Museum and Stevns Tourist Office along with some 110 citizens contributed to the vision work over the winter 2010-2011. A work group under the Steering Group processed the ideas and points of view to phrase the vision, which has been approved by the Steering Group, Stevns Municipality's Municipal Council and the Board of Østsjælland Museum.

The vision is applicable through to 2026, and the target group is all active stakeholders in the nominated area and the buffer zones. The vision is supplemented by objectives that support and explain the long-term vision. A number of functional targets have been listed in the following chapters.



A unique geological site

3.1 The Vision for Stevns Klint

The vision 'Stevns Klint 2026' is not merely a shared dream, but a guiding star that indicates the preferred, future condition of the nominated area. The vision is a realistic description of how Stevns Klint and the human relation to a future World Heritage Site will appear in 2026.

As all players who are involved in the management and development of Stevns Klint accept an obligation to control and strive to follow the vision, it contributes to connecting present and future and to creating coordination and unambiguous direction for Stevns Klint. Thus, the vision is important in relation to current and future plans and strategies for Stevns Klint.

Stevns Klint 2026

Stevns Klint is a well-conserved World Heritage Site with an outstanding geological locality, which is managed and developed on a sustainable foundation with due respect for both natural and cultural values for the benefit of present and coming generations.

The users and the local citizens' relationship to Stevns Klint is characterised by co-existence, respect for and understanding of the World Heritage and the area's other natural and cultural values and by the will to protect and maintain the integrity of Stevns Klint.

Visitors from across the world travel to Stevns Klint to experience the dramatic, geological formations and learn about the cliff's natural and cultural history on a background of research-based dissemination. Tourism is distinctly sustainable, which implies that it is possible to offer quality experiences while at the same time protecting and conserving the World Heritage values.

In the wake of the recognition of Stevns Klint as UNESCO World Heritage, new local employment opportunities emerge within nature preservation, presentation and tourism as well as in the construction and service sectors.

3.2 Objectives

The Stevns Klint 2026 vision is long-term and points towards the general end target. However, in order to convert the vision to reality, it is necessary to set out a number of objectives that will support and clarify the vision.

The overall objective for Stevns Klint is to ensure protection, scientific studies and communication of the values that form the basis for the nomination of the area to be inscribed on UNESCO's World Heritage List, i.e. the geological layers in Stevns Klint.

3.2.1 World Heritage

Improvements are needed in the nominated area and the buffer zones in relation to the measures that protect and conserve the geological values along the entire Stevns Klint. A well-conserved World Heritage Site managed on a sustainable foundation presupposes focus on nature preservation, communication and control of visitors.

The visual beauty of the area must be maintained. More than anything, this involves protecting the natural cliff against measures that will affect the visual experience.

3.2.2 Control

The Steering Group for Stevns Klint is to ensure efficient and holistic control. Based on legislation and plans for the area, solutions must be supplied that meet the requirements on management of Stevns Klint posed by the UNESCO World Heritage Convention and the local community.

A strong network of players is to form the foundation for efficient and coordinated management and development of Stevns Klint. **The distribution of responsibility for the different management and development tasks must be unambiguous.** Everybody must contribute with their competences in order to fulfil the Stevns Klint 2026 vision.

3.2.3 Local involvement

Local citizens must be given the opportunity to be heard and included in decisions that concern their everyday life in the World Heritage area and the buffer zones. This is to create good solutions for the benefit of everybody and contribute to strengthening the local anchoring and ownership, which is considered a strong safeguarding of Stevns Klint's integrity.

The players involved in the management of Stevns Klint are to maintain a good dialogue with plot owners and other local citizens, and this is to create fertile soil for pride, respect for and understanding of the area's special values.

3.2.4 Tourism

Stevns Klint is to be able to attract tourists from every part of the world. This means that not only should efficient management of the World Heritage Site be in place, but information and marketing should also be goal-oriented.

Tourism at Stevns is to be developed on a sustainable foundation. Sustainable tourism firstly means that activities for visitors must not place a strain on the values of Stevns Klint and the other natural and cultural values in the World Heritage area and the buffer zones. Secondly, it means consideration for the local community and their general well-being. Thirdly, it implies local anchoring of growth in the tourist-

related businesses.

3.2.5 Presentation and research

Presentation of Stevns Klint must be developed professionally and targeted at different types of visitors. Both conventional and modern presentation platforms are to be used.

The presentation must be research-based. This implies that research is conducted about the geological processes and that research results and their significance are made comprehensible to the general public. Therefore, a good setting should be created for research to be carried out and for anchoring research results in the area. Increased knowledge and understanding of the outstanding universal value of Stevns Klint's stratification is not only an objective in itself, it is also a way of protecting the core value.

3.2.6 Traffic infrastructure

The traffic-related infrastructure to Stevns Klint must be improved with due consideration for the local community. This entails preparing a road traffic action plan for Stevns Municipality.

3.2.7 Activities along Stevns Klint

It must be possible to use parts of the area along Stevns Klint for recreational purposes without affecting neither the outstanding universal value nor the integrity of Stevns Klint. Information about permitted and prohibited recreational activities must be improved and presented so that there is no doubt about activities in the nominated area and the buffer zones.

Regulations and safety measures for traffic in the area along Stevns Klint must be improved with due consideration given to maintaining the integrity of Stevns Klint.



Stevns Klint

4 Protection and Conservation of Stevns Klint

Efficient protection of the outstanding universal values at Stevns Klint is to ensure that the nominated area can be passed on from the present to future generations. It is therefore of decisive importance to safeguard the values and the integrity of the nominated area.¹

The application for inscription on UNESCO's World Heritage List entails an obligation to protect and conserve Stevns Klint today and in the future. This is an obligation that all involved players accept with great humility and favour.

This chapter deals solely with the protection and conservation of the geological values at Stevns Klint. The following chapters focus on nature preservation along the cliff edge, research and presentation of Stevns Klint, sustainable tourism in the area and the infrastructure to and at Stevns. These subjects are also important to maintain an efficient protection of the nominated area and the area's other natural and cultural values and conservation of the area's integrity.



The waves of The Baltic Sea waves create continual erosion of Stevns Klint

4.1 Protection and conservation of the geological values

Stevns Klint's geological values are affected both by the forces of nature and by human activities. It is therefore important to see the protection of the nominated area in relation to these factors.

¹ UNESCO (2008): *Operational Guidelines for the Implementation of the World Heritage Convention*, World Heritage Centre.

The Baltic Sea's impact on Stevns Klint is decisive for the protection of the core values and the conservation of the nominated area's integrity. The Baltic Sea's waves create continual erosion of Stevns Klint, which prevents overgrowth and wear and adds new, fresh exposures of the geological layers. Should this natural process be stopped via coastal protection, the long-term effect would be that the geological stratification would blur and plants would grow. Such a scenario cannot be considered neither protection nor conservation of the complete and very visible geological series of layers for coming generations – in other words, the integrity of the area would be at risk. An unprotected coast, on the other hand – although this may seem like a paradox – is a basic prerequisite for the protection of the outstanding universal value and the conservation of the integrity of Stevns Klint.

The human factor has had an impact through centuries of raw material extraction. As it will appear from the following Chapter, raw material extraction is limited today, but visible traces remain from previous raw material extraction in certain places at Stevns Klint. Collecting of fossils and other geological material constitutes another potential challenge to the maintenance of the nominated area's integrity. Designation as a UNESCO World Heritage Site is not likely to increase interest from the world of research, which already pays great attention to Stevns Klint due to the complete geological layer series. However, it is possible that other visitors will be interested in taking a memento with them from Stevns Klint in the form of a fossil, a petrified item, a nice piece of limestone or a flint stone or some fish clay. Whether geological material ends up in laboratories or in private homes, it is important to keep control of the collecting of material so that the integrity of Stevns Klint is not put at risk.

4.1.1 Current situation

As described in Chapter 2.1, the Outstanding Universal Value is found along the entire Stevns Klint, in Boesdal Kalkbrud, Cold War Museum Stevnsfort's underground passages, Holtug Kridtbrud and beneath the surface of the sea by Cold War Museum Stevnsfort. These are the localities that need protection and conservation. Towards the end of this Chapter, there is an account of the current situation concerning raw material extraction and the collecting of geological material for research and souvenirs.

Coastline

Today, waves from the Baltic Sea cause erosion of Stevns Klint along the entire 17-kilometre coastline. The only exceptions are small areas with coast protection by Højerup and Boesdal Kalkbrud. Below Højerup Old Church, there is an approximately 60 metres long and 20 metres wide coastal protection zone. The old Medieval church is located dramatically on the cliff edge after it lost its choir during a large cliff slide in 1928. Coastal protection was set up in order to protect the rest of the church, which is now listed, from crashing down from the cliff edge. By Boesdal Kalkbrud, the remains of an old harbour constitute a 20 metres long and 5 metres wide coastal protection zone at the opening of the cliff. Coastal erosion along Stevns Klint does not threaten facilities of vital importance to a lot of people, and should Stevns Municipality in future receive an application about the establishment of coastal protection in the nominated area, the Act on Coastal Protection ensures that the need for coastal protection will be balanced against the conservation of the coastal landscape and the free development of nature.² Stevns Municipality – who manages the legislation on coastal protection – thus assesses that very heavy arguments will have to be presented in order to obtain approval for coastal protection facilities.

The Act on the Protection of Nature's Section 15 also helps protect Stevns Klint.³ The Act stipulates concrete prohibitions in a zone that reaches 300 metres inland. For instance, it is prohibited to alter the terrain, add soil or plant trees and bushes, which would otherwise affect the core values of Stevns Klint negatively. The Danish Nature Agency in Roskilde is the public authority that administers this Section of the Act and does so strictly.

² *Act on Coastal Protection*, Consolidated Act no. 267 of 11 March 2009 Section 1, Ministry of Transport.

³ *Act on the Protection of Nature*, Consolidated Act no. 933 of 24 September 2009 Section 15, Ministry of the Environment, and Ministry of the Environment (2010): *Strandbeskyttelseslinjen (The Beach Protection Line)*, The Town and Landscape Agency. See <http://www.naturstyrelsen.dk/NR/rdonlyres/EE504509-CA50-42BB-A9D2-B46C496BC015/109858/Landskabsversion110510.pdf>.

In a few localities along Stevns Klint, there are traces after raw material extraction in former times. The abandoned quarries at Boesdal and Holtug are the most visible. The areas' protection and conservation are dealt with separately below, as both areas currently contribute to the integrity of Stevns Klint. However, there are also other traces of raw material extraction. In the mid-1800s, a production of building stones sawn directly out of the cliff was started. Today, Stevns Klint carries traces of this quarrying in several places. These traces are called cuts. There are also various traces of lifting devices, which would have been used in connection with hoisting limestone or fishing boats.

These traces form part of the culture-historical story about Stevns Klint. As they belong to the past and in the long term will be erased as a consequence of landslides, it is assessed that the culture-historical traces do not represent any danger for the integrity of the nominated area.

In conclusion, it should be stressed that the current conditions on the coastline between Rødvig and Bøgeskov cause continual erosion whereby new, fresh exposures become visible in Stevns Klint. The natural coastal erosion offers the primary protection of the nominated area and helps create and conserve the cliff. Erosion causes the cliff profile to move further inland. Mapping has shown that the boundary layers extend landwards beneath the present day landscape, and based on average present day and historic erosion rates, the boundary layers will be exposed in good quality sections for a minimum of 20,000 years.

Boesdal Kalkbrud

The limestone quarry Boesdal Kalkbrud includes a south-facing cliff profile by the open air stage in the nominated area. The profile's geological layer series is a particularly good example of a symmetrical bank form and it therefore contributes to support the integrity of Stevns Klint. The impressive rock wall is only affected very slowly by natural erosion caused by precipitation. There is no human influence on this core



Traces of cuts

value. Section 15 of the Act on the Protection of Nature applies to the area. Boesdal Kalkbrud is also subject to management in accordance with the Planning Act. The different Acts are assessed to constitute sufficient protection of the nominated area in Boesdal Kalkbrud.

Cold War Museum Stevnsfort

The underground passages in Cold War Museum Stevnsfort form part of the nominated area. In the 1.6 kilometre passage system, it is possible to see the geological stratification in three dimensions. The stratification is well protected, as the underground passages are only accessible via the Museum's guided tours. Additionally, Cold War Museum Stevnsfort is working to have the area's buildings listed, including the underground passages, cf. Chapter 7.1.4.

The seafloor off Stevns Klint

Along part of the coastline around Cold War Museum Stevnsfort, the limestone banks on the seafloor are visible. The outline of the limestone banks contributes to the cliff's integrity and is included in the core area. The limestone banks off Stevns Klint are within the area that is covered by the European Union's Directive on Natura 2000 nature preservation. The Directive is implemented in Danish legislation via the Act on Environmental Objectives.⁴ As mentioned in Chapter 2.2.3, the area is also covered by prohibitions against suction, digging and boulder fishing in accordance with applicable national legislation, which protects the area's geological values.⁵

Holtug Kridtbrud

The chalk quarry Holtug Kridtbrud is also a protected Natura 2000 area, which is furthermore protected under the Act on the Protection of Nature. What is special about the area from a geological point of view is that a version of the bryozoan banks that is particularly low in bryozoans is visible, which complements Stevns Klint's integrity.

Holtug Kridtbrud is an excellent place for finding fossils and petrified items, and findings in the quarry include *Danekræ* (fossil trove), i.e. natural history objects of outstanding scientific or exhibitional value. Fossil trove belongs to the State.⁶ The geological value that fossils and petrified items constitute is also important in relation to the conservation of the area's integrity.

Raw material extraction

Pursuant to the Act on Raw Materials, Region Zealand has prepared a raw materials plan, which establishes where it is permitted to dig for sand, gravel, stones and clay as well as limestone and chalk.⁷ In this Raw Materials Plan, digging areas and interest areas have been designated/laid out. The objective of the laying out of areas is to ensure that the areas are not laid out for purposes that might prevent or complicate future raw material extraction. It is also to be ensured that raw material extraction only takes place within the designated digging areas.

As a rule, the Municipality is under obligation to grant permission for raw material extraction within the digging areas covered by the Raw Materials Plan, with due consideration for special protection interests, including ancient monuments, protection of habitats etc.

Before the areas are used for other purposes, it must be ensured that studies are carried out within the

⁴ Council Directive 92/43/EEC of 21 May 1992 on the Preservation of Habitats and Fauna and Flora. Act on Environmental Objectives, Consolidated Act no. 932 of 24 September 2009, Ministry of the Environment.

⁵ Executive Order on Prohibition against Exploration and Extraction of Raw Materials from the Seafloor within EU Bird Protection Areas and in Ramsar Areas, Executive Order no. 984 of 5 December 1994, Ministry of the Environment.

⁶ Executive Order on the Museum Act, Consolidated Act no. 1505 of 14 December 2006, Ministry of Culture, Section 31.

⁷ Region Zealand (2008): *Råstofplan for Region Sjælland 2008 (Raw Materials Plan for Region Zealand)*, Sorø.



View of Holtug Kridtbrud

interest areas to ascertain whether they contain raw materials that can be extracted. Normally, no digging permission will be granted within the interest areas unless social interests speak in favour of this and provided it does not conflict with significant interests, and that the existence of a deposit is documented.

The Raw Materials Plan is Stevns Municipality's administrative basis for decisions on raw material extraction. Any permission to commence raw material extraction will be given on the basis of the Raw Materials Plan's guidelines. In Stevns Municipality, digging areas have been designated around the chalk quarry Sigerslev Kridtbrud, which is the Municipality's only active quarry.

Stevns Klint has been designated an Area of National Geological Interest⁸, which means that the area is of fundamental importance to the understanding of Denmark's geological development. Legislation stipulates that Areas of National Geological Interest must be safeguarded and conserved. Furthermore, Pro-Geo – The European Association for the Conservation of the Geological Heritage – has designated Stevns Klint a GeoSite, which means that Stevns Klint is included in a network of particularly important European geological areas of scientific significance.

Stevns Municipal Plan⁹ contains guidelines that are to secure general geological conservation values, including the location of areas of particular geological value in relation to the current Planning Act.¹⁰ In comments to the Act, it is stated that valuable geological landscape features, their mutual transitions and correlations are to be safeguarded and that valuable geological coast profiles are to be conserved.

⁸ See the Danish Nature Agency (2011) *Oversigt over statslige interesser i kommuneplanlægningen 2013 (Overview of State Interests in Municipal Planning 2013)*, Ministry of the Environment, Copenhagen.

⁹ Stevns Municipality (2009): *Stevns Municipal Plan 09*, Stevns.

¹⁰ *Act on Planning*, Consolidated Act no. 937 of 24 September 2009, Section 11a, subsection 1, item 16, Ministry of the Environment. Also see the Danish Nature Agency (2011) *Oversigt over statslige interesser i kommuneplanlægningen 2013 (Overview of State Interests in Municipal Planning 2013)*, Ministry of the Environment, Copenhagen.

In comments to the legislation, it has been specified that the quality of Areas of National Geological Interest is not to be reduced by obscuring or destruction through digging, building, technical facilities, forest planting or similar. In terms of protection, GeoSites are ranked alongside Areas of National Geological Interest.

Given its status as an Area of National Geological Interest and a European GeoSite along with the Act on the Protection of Nature, the Act on Planning's restrictions and the Regional Plan for Region Zealand, Stevns Klint is currently well protected against raw material extraction. As mentioned above, it is prohibited to alter the terrain and dig away raw materials within the 100 metres closest to the coast pursuant to Section 15 of the Act on the Protection of Nature. Furthermore, it is not possible to obtain permission for raw material extraction within an Area of National Geological Interest. Thus, Stevns Klint is well protected against raw material extraction today and in the future.

Currently, there are registered rights for chalk and limestone along the entire coastline. The rights belong to the Gjorslev Estate and they do not lapse until 1 July 2028.¹¹ In order to exploit registered rights, a permission for extraction must be obtained from Stevns Municipality. In accordance with the above, no permissions for raw material extraction will be granted in the vicinity of Stevns Klint's core values. As a rule, a rejection of such an application will be an expropriation measure, and rights owners will be entitled to claim damages.¹² Should it be possible to demonstrate that social interests are at stake, it is possible to dispense with this rule. The settlement of any compensation claim will rest with the State. Questions about compensation must be solved by a court of law.

Currently, raw material extraction along Stevns Klint is limited to Sigerslev Kridtbrud. This chalk quarry is situated outside the nominated area. The raw material source at Sigerslev Kridtbrud is expected to last some 25-30 years, before it may become necessary to include new areas for the extraction of raw material. OMYA A/S has leased the raw material extraction rights and has permission to extract in designated areas in Sigerslev Kridtbrud up until 1 July 2013. By the coast, the geological stratification has been quarried to a width of 157 metres. However, quarrying no longer takes place by the edge, and as mentioned, no permission will be granted for this in future because Stevns Klint is an Area of National Geological Interest. Instead, quarrying takes place further inland, and thus it no longer constitutes a threat to the conservation of Stevns Klint. Concurrent with the raw material extraction, a reestablishment of the emptied parts of the chalk quarry is taking place, and gradually, the area will be re-established as a nature and recreational area. In accordance with the permission, OMYA A/S is to establish at least one geological profile in the chalk quarry in collaboration with Østsjælland's Museum, and an information board is to be erected by the profile.¹³ Thus, in the long term, Sigerslev Kridtbrud will come to constitute a complementary contribution to the nominated area.

The Danish Nature Conservancy Board has not found further listing necessary. The reasons given for this are that 1) there are sufficient raw material reserves in areas less close to the coast; 2) the Municipality must give its permission for extraction to begin, and 3) the Act on the Protection of Nature was administered strictly. The Danish Nature Complaints Board later ratified this decision with the conclusion that raw material extraction does not constitute a concrete threat in the areas along Stevns Klint, and that Stevns Klint is sufficiently protected by existing legislation.¹⁴

Collecting of geological material

Geological materials are collected by local citizens, tourists, educational institutions, amateur geologists and researchers. Collecting by local citizens and tourists can be characterised as minor and is typically carried out without the use of tools. However, it is to be expected that this type of collecting will increase once the story about Stevns Klint becomes better known. It is especially expected that the collecting of

¹¹ *Act on Raw Materials*, Consolidated Act no. 950 of 24 September 2009, Ministry of the Environment.

¹² *The Constitution of the Kingdom of Denmark*, ACT no. 169 of 5 June 1953, Prime Minister's Office, Section 73.

¹³ Stevns Municipality (2001): *Tilladelse til indvinding af kridt i Stevns Kridtbrud i Stevns Kommune (Permission for Extraction of Chalk in Stevns Kridtbrud in Stevns Municipality)*, File no. 8-70-30-389-1-2001.

¹⁴ Decision from the Nature Conservancy Board dated 14 November 2003 and decision from the Nature Complaints Board dated 27 August 2004 about conservation of Stevns Klint.



Concentrated forssil hunter

fish clay will increase in the most easily accessible localities close to the car parks.

Collecting carried out by educational institutions often consists of individual fossils and is typically carried out with the use of hammer and chisel. However, a few examples of educational institutions collecting large amounts of material have been registered by plot owners. Collecting done by students for educational institutions is expected to increase, especially around the most easily accessible localities by Høj-erup, Holtug and on the stretch between Rødvig and Boesdal Kalkbrud.

Amateur geologists from Denmark and abroad have been collecting along Stevns Klint for several years. Collecting typically takes place along the entire length of the cliff. Some amateur geologists' collections are made available to research and constitute significant collections. As Stevns Klint is already well known among amateur collectors, it is expected that this kind of collecting will not increase significantly.

Stevns Klint is internationally known among researchers whose field of interest includes the famous geological boundary with traces of mass extinction. Researchers from across the world come to Stevns Klint to study the fish clay, compare fauna in the Cretaceous and the Tertiary Periods etc. To a great degree, the research that is related to Stevns Klint is carried out on the basis of analyses of geological material. The fact that researchers to some extent remove geological material from Stevns Klint can be justified by the fact that research provides new knowledge about Earth's history. Collecting of material for research purposes takes place along the entire cliff and typically in small amounts. However, large-scale collecting does occur.

Collecting of geological material for research is not currently registered. This means that no overview exists of the extent of collected material, of the localities where the material is collected or of the results generated by research based on the collected material.

Minor collecting of geological material from public property can be justified with reference to the Jutlandic Law from 1241. This Law is no longer valid in legal terms, but it is used as a moral guiding principle. The Jutlandic Law stipulates that it is permitted to collect geological materials as long as they are only small items, which are defined as, "what you can fit into your hat".¹⁵

If materials are to be collected in greater amounts, Stevns Municipality, the Danish Nature Agency or the Danish Coastal Authority must be contacted, and it may be necessary to apply for permission pursuant to the regulations contained in the Act on the Protection of Nature and/or the Act on Raw Materials. Whether researchers comply with this rule is not known.

On private property, regulations about private property rights apply. In principle, any person wanting to collect geological material should ask permission from the owner before doing so. The owner has a right to forbid the collector to take anything.¹⁶

As things stand today, there is no checking or control of collecting of geological material. This would be desirable, as it would help secure an efficient protection and conservation of Stevns Klint and its integrity. Increased control would also lead to increased knowledge about research in the area and the possibility of communicating new knowledge on site. Østsjælland Museum and Stevns Municipality are currently studying the possibilities of increasing checking and control of the collecting of geological material, cf. Chapter 4.1.4.

4.1.2 Challenges

Although Stevns Klint is currently well protected in relation to natural and human influences, certain challenges need to and must be resolved in the long term.

The challenges consist in:
Monitoring and controlling collecting of geological material by tourists, educational institutions, amateur geologists and researchers.
Re-establishing Sigerslev Kridtbrud – despite the fact that this is not part of the nominated area – as a sustainable nature area, which contributes positively to the overall experience of Stevns Klint.

4.1.3 Objectives for protection and conservation

The geological values along the entire Stevns Klint must be protected and conserved for present and future generations.

Objectives for protection and conservation
Implementation of an efficient system for monitoring Stevns Klint with a view to monitoring and controlling the collecting of geological material and any wear and tear.
Implementation of a code of practice for collecting of geological material.
Information about the outstanding universal values and the importance of safeguarding the nominated area.

4.1.4 Measures

In order to better protect and conserve Stevns Klint, it is advisable that measures be taken that would regulate human impact on the nominated area. The measures listed below are aimed at the physical impact on the core values.

Information and instruction will also contribute to protecting the core values and the integrity of Stevns Klint. This is dealt with in Chapter 6.

¹⁵ See <http://www.naturstyrelsen.dk/Naturoplevelser/Adgang/Samle/SandOgSten.htm>

¹⁶ See <http://www.naturstyrelsen.dk/Naturoplevelser/Adgang/Samle/SandOgSten.htm>

No.	Measure	Content	Time schedule	Responsibility
1	Organisation	An organisation is to be established with knowledge about the core values, presentation and monitoring. The organisation is to ensure a professional and management-related change and thereby funding of the tasks related to presentation and monitoring of the core values.	2012	Stevns Municipality Østsjællandss Museum
2	Mapping	The impact on Stevns Klint is to be mapped, including the extent of the collecting of geological material for research.	2012 Awaiting funding	Østsjællandss Museum
3	Action plan for geology at Stevns Klint	An action plan is to be prepared for geology at Stevns Klint with a view to protecting and conserving the state of the outstanding universal value.	2012	Stevns Municipality Østsjællandss Museum
4	Permission for collecting of geological material	Specific requirements about permissions for collecting of geological material for research are to be drawn up.	2012	Stevns Municipality Østsjællandss Museum
5	Plan for control of visitors	A plan for the control of visitors is to be prepared. The plan is to ensure that the core values are presented to visitors, while at the same time the impact on the nominated area is limited.	2012	Østsjællandss Museum Stevns Municipality Stevns Tourist Office
6	Monitoring	An efficient system for monitoring the condition of Stevns Klint is to be developed and implemented.	2012 Awaiting funding	Østsjællandss Museum
7	Executive Order on Law Enforcement	It is to be determined whether and how an Executive Order on Law Enforcement for Stevns Klint can be prepared, which the Police would be able to enforce.	2012	Stevns Municipality
8	Anchoring of knowledge in dissemination	It is also to be investigated how research results from Stevns Klint can reach Østsjællandss Museum with a view to dissemination.	2012	Østsjællandss Museum
9	Focus group for Sigerslev Kridtbrud	Efforts are to be made to reactivate the focus group for Sigerslev Kridtbrud.	2012	Stevns Municipality
10	Study of coastal protection	It is to be checked whether there are legal provisions to have coastal protection by Præsteskov removed.	2011-12	The Danish Coastal Authority

5 Nature Preservation

Stevns Klint is more than world-class geology. It is also an exquisite nature area with rich and varied fauna and flora. Pastures along the top edge of Stevns Klint contribute to a nature area with many different species, which complement the overall experience of Stevns Klint. Nature preservation is imperative in order to ensure a complete nature experience in the nominated area.

5.1 Nature at Stevns Klint

Nature along Stevns Klint is diverse. The pastures are more or less typical limestone pastures, and they are protected under the Act on the Protection of Nature.¹ The pastures and the pasture flora are marked by the limestone that is not far below ground. The pastures are home to several interesting plants, insects and small animals. For instance, there are sand lizards, which are not only registered on the Danish Red List of animal and plant species, but also protected under the European Union's Habitat Directive.² The sand lizard is highlighted as an example because this reptile is an indicator of how well flora and fauna thrive on the pastures that are exposed to sunlight. Stevns Municipality has prepared an action plan for sand lizards with a view to targeting the management effort at ensuring the survival of the population in Stevns Municipality.³



Sand lizard

Stevns Klint is one of Denmark's best places for migratory birds; from the cliff edge, the spectacular sight of large bird migrations can be enjoyed as they pass over the area, coming from the Baltic Sea. Birds of prey are particularly noticeable, as somewhere between 20,000 and 25,000 birds of prey fly via Stevns Klint every year.

¹ *Act on the Protection of Nature*, Consolidated Act no. 933 of 24 September 2009 Section 3.

² *Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Habitats and Fauna and Flora*, The European Union. The Directive is implemented into Danish legislation via the *Act on Environmental Objectives*, Consolidated Act no. 932 of 24 September 2009, Ministry of the Environment.

³ Stevns Municipality (2011): *Handlingsplan for Markfirben i Stevns Kommune (Action Plan for Sand Lizards in Stevns Municipality)*, Stevns. See http://www.stevns.dk/files/cache/20090505080745f4f506a36d4746d3aa451e10c2028940/Markfirben_Handlingsplan_2.pdf

The peregrine falcon is among the interesting birds of prey at Stevns Klint; on the Danish Red List, this bird is registered as extinct, and thus, it is a very rare Danish breeding bird. One of just three pairs in Denmark breeds at Stevns Klint. In legal terms, the peregrine falcon is protected through conservation⁴ and the European Union's Birds Directive.⁵ The Danish Nature Agency, Stevns Municipality, the Danish Ornithology Association and the Royal Danish Aero Club collaborate to protect the peregrine falcon at Stevns Klint.

The common rosefinch population is more widespread. In Denmark, the population has been declining over the past 10 years, which means that the species is moderately threatened. However, the common rosefinch has been registered along the entire Stevns Klint. Similar to the more common nightingale, the common rosefinch does not thrive particularly well in nature areas with pasture, whereas it does thrive in areas with bushes, scrub or forest. Stevns Municipality is aware of this issue, and consequently, nature preservation along Stevns Klint also involves care for trees, bushes and scrub.

Stevns Klint is a sleeping and hibernation place for a large number of bat species. Seven out of Denmark's 17 known species live by the cliff. These species are all listed and protected under the European Union's Habitat Directive.⁶ Stevns Klint is attractive because of its many fissures and caves. The bats find shelter here during the day when they rest. The cliff is also a good starting point for the night's hunt, which takes the bats along stands of trees, meadows and other places where they find food. During winter, the bats squeeze into deep fissures and cavities that maintain a temperature of 2-8 °C. In this way, the bats make it through the winter where there is little access to food.

The flora is typical pasture flora and it thrives along Stevns Klint. In 1976, an overview was elaborated of the species found along Stevns Klint.⁷ Today, most of the species that are mentioned in the overview can be found again. Two species, the bloody cranesbill and the rock rose have all but disappeared today. It should also be mentioned that there is a large seed pool in the ground, which is evident by the fact that the pasture flora starts growing after just a few years without fertiliser and care.

5.2 Pasture, scrub and forest

Historically, the upper edge of Stevns Klint was covered in forest, but during the Stone Age, man left his mark on nature by clearing areas to give room for grazing cattle. This led to the creation of a pasture landscape poor in nutrition but very rich in species. However, the development of agricultural production meant that the grazing areas were gradually converted to crop production. This development continued up until the end of the 1980s, where areas of natural value along Stevns Klint only covered about 25 hectares. Since then, the development has been reversed via a deliberate effort to recreate pastures and other habitats.

All nature areas along Stevns Klint are managed in accordance with the Act on Planning and the Act on the Protection of Nature.⁸

5.2.1 Current situation

With recent decades' increased focus on natural values along Stevns Klint, Stevns Municipality has succeeded in recreating important natural areas. Today, there are seven large nature areas with great biodiversity along Stevns Klint covering a total of about 70 hectares. The nature areas mainly consist of pastures or areas that are cared for with a view to re-establishing pastures. However, there are also smaller nature areas characterised by scrub and forest. The nature areas are connected via a narrow strip along Stevns Klint, which a number of the involved players look after.

⁴ Executive Order on Protection of Certain Animal and Plant species etc., Capturing and Trading Game and Caring for Injured Game, Executive Order no. 901 of 11 July 2007, Ministry of the Environment.

⁵ Council Directive 79/409/EEC of 2 April 1979 on the Protection of Wild Birds, the European Union.

⁶ Council Directive 92/43/EEC of 21 May 1992 on the Protection of Habitats and Fauna and Flora, the European Union.

⁷ Palle Gravesen (1976): *Oversigt over botaniske lokaliteter – Sjælland (Overview of Botanical Localities – Zealand)*, Danish Conservation Agency, Copenhagen.

⁸ Act on Planning, Consolidated Act no. 937 of 24 September 2009, Ministry of the Environment, and Act on the Protection of Nature, Consolidated Act no. 933 of 24 September 2009, Ministry of the Environment.

Nature areas along Stevns Klint



commons Forest / scrub

Boesdal Kalkbrud

The abandoned limestone quarry Boesdal Kalkbrud is undergoing a long-term development towards becoming a nature area with respect for the geological values. A very fine pasture flora has been developed, and a large part of the abandoned quarry is protected under the Act on the Protection of Nature. The vegetation structure is linked to the natural overgrowth dynamics in the area, which has been supplemented by efforts to improve growth conditions. Work is also in progress to conserve the pasture flora with Common Centaury, Anthyllis, Rockcress and a special variety of Carline Thistle and more. The area includes extensive growth of wild Clematis, which may constitute a problem in the long term, as this plant's growth is quite aggressive. The dominant tree species are elm, willow, hawthorn and elder. In recent years, trees and bushes have been removed, which are not native to the pasture or which would grow up and threaten the pasture. For instance, maple, as this is an imported species, which can grow quickly to form a forest.

As regards animals, there is a relatively large and important population of sand lizards in the limestone quarry, and in recent years, a new species – in Danish terms – has been registered, i.e. the moth Silvery Gem along with the rare moth, the Small Emerald. Both species have a healthy and permanent population in Boesdal.

Nature preservation of Boesdal Kalkbrud is described in the Local Plan for the area.⁹ Stevns Municipality handles nature preservation.

Cold War Museum Stevnsfort

The nature around Cold War Museum Stevnsfort is characterised by pasture with appertaining pasture flora and fauna. However, scrub and a small forest are also found in the area. The plant species that should be conserved in the area include Common Centaury, Common Goldenrod, Peach-leaved Bellflower, Harebell, Wild Carrot, Origanum and Carline Thistle. Birds such as the popular nightingale and the rare common rosefinch stay in the forest and the scrub.

Nature preservation of Cold War Museum Stevnsfort is described in the Local Plan for the area.¹⁰ Østsjællandss Museum is working on a revision of the preservation plan. Østsjællandss Museum handles nature preservation within all of the Museum's areas, partly with help from the Museum's groups of volunteers. The area between the Museum and the cliff edge is managed and looked after by Stevns Municipality.

Højerup

Højerup includes the only forest area along Stevns Klint. The rest of the area is characterised by pasture. A rich flora and fauna is found at Højerup. For instance, Milkwort is found in great numbers on the meadow outside Stevns Museum, and the almost extinct species of Rock Rose is found on the slopes by Højerup.

The society Selskabet Højeruplund and Østsjællandss Museum are responsible for nature preservation on their respective plots of land.

Stevns Lighthouse, Stevns Fyr

The area around Stevns Lighthouse (Stevns Fyr) is rich in birds and plants. The area is characterised by scrub and pasture. The vegetation consists mainly of maple, ash, hawthorn, bramble, dewberry and roses. The trees and bushes constitute important habitats for birds such as the nightingale and the common rosefinch.

The Local Plan for Stevns Lighthouse includes a preservation plan for the area, in which the preservation of trees and bushes, low vegetation and pasture is described.¹¹ Stevns Municipality is responsible for na-

⁹ Stevns Municipality (2007): *Local Plan 47 for Boesdal Kalkbrud*, Dept. of Technology & Environment. See <http://www.stevnskom.dk/Lokalplaner/47.pdf>.

¹⁰ Stevns Municipality (2007): *Local Plan 77a, Cold War Museum Stevnsfort*, Dept. of Technology & Environment. See <http://www.stevns.dk/lib/file.aspx?fileID=1055&target=blank>.

¹¹ Stevns Municipality (2006): *Local Plan 73, Stevns Lighthouse*, Dept. of Technology & Environment. See <http://>

ture preservation.

Stevns Nature Centre – Flagbanken and Mandehoved

The area by Stevns Nature Centre in Mandehoved and Flagbanken is characterised by pasture, some woodland and bushes. A minor population of Knapweed Broomrape is found in the area. The extension of this plant is limited to six habitats in Denmark, which is why Knapweed Broomrape is characterised as rare in Denmark. The species is listed and categorised as near threatened, as its preferred biotopes are in decline.

There is currently no preservation plan for the area, but Stevns Municipality is planning to elaborate a special framework for the area in the course of 2011 and 2012.¹² This framework will include nature preservation. Østsjælland Museum and Stevns Municipality handle the nature preservation work.

Holtug Kridtbrud

Today, the chalk quarry Holtug Kridtbrud forms part of the European Natura 2000 network, the objective of which is to protect nature areas designated and managed pursuant to the European Union's Nature Preservation Directives.¹³ The abandoned quarry is a good example of how it has been possible to re-establish a valuable nature area after the extraction of chalk stopped.

Thus, Holtug Kridtbrud is not only a good place for studying the geology of Stevns Klint, it is also a diverse biotope with interesting fauna and flora. For instance, the area has a minor population of the rare and near threatened plant Knapweed Broomrape – as does the area of Mandehoved – but there are also other interesting plants, including Hieracium Cymosum, Tower Mustard, Dyer's Rocket, Fairy Flax, Butterfly Blue, Peach-leaved Bellflower, Nottingham Catchfly, Wild Liquorice and a particularly rare variety of Carline Thistle.

In terms of animal species, it is worth mentioning that a steady population of two rare species of moths have established themselves here – the same species that have settled in Boesdal Kalkbrud – while Sand Lizard, Adder, Smooth Newt and other amphibians also thrive in the area. The largest adder population along Stevns Klint is found in Holtug Kridtbrud.

The area and its species are protected pursuant to the European Union's Nature Conservation Directive and Danish legislation. The Danish Nature Agency is responsible for nature preservation at Holtug Kridtbrud.



The Fish Clay

www.stevnskom.dk/Lokalplaner/Lok73E.pdf.

¹² Stevns Municipality (2009): *Stevns Municipal Plan 09*, Stevns, p. 295.

¹³ Ministry of the Environment (2009): *Forslag til Natura 2000-plan 2009-2015. Holtug Kridtbrud, Natura 2000-område nr. 182, Habitatområde H183 (Proposal for Natura 2000 Plan 2009-2015. Holtug Kridtbrud, Natura 2000 area no. 182. Habitat area H183)*, Roskilde. See http://www2.blst.dk/publikationer/naturplanforslag/182_HoltugKrid.pdf.

5.2.2 Challenges

Challenges related to conducting nature preservation along Stevns Klint are primarily related to the agricultural production in the area. However, it should be stressed that agriculture does not constitute a threat to the nominated area, as the agricultural production does not affect the geological layers located deeper in Stevns Klint.

The challenges consist in:
Cultivated agricultural areas constituting a barrier between the nature areas, which affects the spreading of animals and plants negatively. Stevns Klint itself and the beach compensate for this problem to some degree.
The use of fertilisers and chemical pest control agents in the agricultural production having a negative effect on parts of the natural areas, including the spreading of animals and plants.
Combating invasive species.
Open air activities – such as unleashed dogs and paragliding – is a problem to certain species in a few localities.

5.2.3 Objectives for nature preservation

In Stevns Municipal Plan, Stevns Klint is designated a 'particularly valuable nature area'. This implies that no alterations must take place in the area without extensive consideration for Stevns Klint's geology, nature and landscape value.

Nature preservation objectives
More and larger areas of pasture are to be established along Stevns Klint.
The existing nature areas must be tended, so that pasture with a rich biodiversity can be recreated.
Invasive flora must be combated.
Native plants must be conserved.
A pesticide and fertiliser-free zone of 20 metres must be established along the upper edge of Stevns Klint.
In the long term, a cultivation-free zone is to be established along Stevns Klint.

5.2.4 Measures

In the coming years, Stevns Municipality, Østsjælland's Museum and the Danish Society for Nature Conservation's local branch will launch a number of initiatives with the objective of encouraging sustainable development of existing nature areas, so that visitors may experience an exciting nature with great biodiversity along Stevns Klint. Preservation of the pasture areas will increase the diversity of plants and benefit the population of insects.

No.	Measure	Content	Time schedule	Responsibility
11	Nature Policy for Stevns Municipality	A nature policy is being prepared for all of Stevns, which is to establish the overall framework for the future prioritisation and development of nature in the Municipality as well as focus on development in the individual nature areas.	2012	Stevns Municipality
12	Mapping of nature along Stevns Klint	A review of the nature along Stevns Klint is planned with the objective of gaining an exact image of the state of the nature. This includes mapping of species protected under the EU Habitat Directive, species on the Danish Red List and nature areas protected under the Act on the Preservation of Nature.	2011	Stevns Municipality in collaboration with the biological consultancy company Aglaja
13	Nature preservation along Stevns Klint	Work is in progress on launching a number of projects that are to focus on sustainable development of existing nature areas and accessibility to nature.	Awaiting funding	Stevns Municipality Østsjællandss Museum Danish Society for Nature Conservation local branch
14	New preservation plan for nature by Cold War Museum Stevnsfort	A revised version of the existing Preservation Plan for the area is being prepared. The Plan is to ensure that the great biodiversity is maintained.	2011	Østsjællandss Museum
15	Action plan for bats	An Action Plan for the protection of listed bats is to be prepared.	2011-12	Stevns Municipality Østsjællandss Museum
16	Special framework for Stevns Nature Centre and Flagbanken	A special framework is to be prepared for Stevns Nature Centre and Flagbanken in the coming Municipal Plan. ¹	2013	Stevns Municipality
17	Special framework for Mandehoved	A special framework is to be prepared for Mandehoved in a coming addendum to the Municipal Plan. ²	2011-12	Stevns Municipality
18	Special framework for Holtug Kridtbrud	A special framework is to be prepared for Holtug Kridtbrud in a coming addendum to the Municipal Plan. ³ In 2012, the Danish Nature Agency is to make an Action Plan for preservation of Holtug Kridtbrud.	Not decided	Stevns Municipality

Footnotes

1 Stevns Municipality (2009): Stevns Municipal *Plan 09*, Stevns, p. 295.

2 Stevns Municipality (2009): Stevns Municipal *Plan 09*, Stevns, p. 295.

3 Stevns Municipality (2009): Stevns Municipal *Plan 09*, Stevns, p. 294.

6 Research and Dissemination

It is important that Stevns Klint – as a world-class geological locality – be presented to the general public. The vision and objectives clarify the strong ambition to spread knowledge and learning about Stevns Klint and its outstanding universal value in relation to understanding the development of life. However, it is also desirable to narrate the cultural history that relates to Stevns Klint.

It is important that knowledge communicated to the general public about Stevns Klint be based on scientific research. In this context, important tasks include to secure new research about Stevns Klint and to make the research results meaningful to the different groups of visitors – whether they are schoolchildren, amateur geologists, tourists or others.

Østsjælland's Museum handles research and dissemination, and based on the Museum's experience in dissemination and in-depth local knowledge about the geology, nature and culture at Stevns Klint, the Museum would like to create high-quality presentation offers by procuring new knowledge and making it accessible to visitors.



Guided walk on the beach

6.1 Research

If Østsjælland's Museum is to continue supplying interesting, applicable and relevant knowledge about Stevns Klint to future visitors, it is a prerequisite that the presentation is academically sound and that it takes its starting point in the most recent research within the Museum's fields of work: the geology of limestone and the cultural history that is linked to the limestone.

It was new and groundbreaking research based on Stevns Klint that confirmed the theory that an asteroid impact 65 million years ago contributed to the latest great mass extinction.

6.1.1 Current situation

Østsjælland's Museum's permanent staff includes two research-trained geologists, one historian, one ethnologist and two biologists. In connection with various research projects, the staff is expanded in connection with relevant project-employed researchers.

Østsjælland's Museum is particularly active within research into the geology of limestone based on geological deposits and fossil findings from Stevns Klint and the limestone quarry Faxe Kalkbrud. Through its permanent staff and because of its collaboration with a number of other players, the Museum has achieved considerable results and is active in terms of scientific publications in international, peer-reviewed journals.

In relation to the cultural history that is connected to limestone, the Museum's research is particularly focused on the area of The Cold War through a collaboration agreement with University of Copenhagen. The Museum also conducts surveys of the particular cultural history related to limestone, including quarrying history and construction culture.

6.1.2 Challenges



Fossil hunting

There are only a few challenges in relation to conducting research about Stevns Klint. However, they are significant and in a sense apply to research in general.

The challenges consist in:
Scientists having sufficient material to conduct research.
Ensuring funding for research projects about Stevns Klint.
Having research results published in scientific journals. This implies that the scholarly level of the knowledge production has to be assessed and verified by international researchers.
Anchoring new knowledge locally and communicating it to the general public.

6.1.3 Objectives for research

Østsjælland's Museum focuses particularly on research that contributes new knowledge about Stevns

Klint.

Research objectives
Research about Stevns Klint must be promoted.
Research is to focus on the geology of limestone, but also on the cultural history of limestone and The Cold War. Østsjællandss Museum is to focus on these research areas today and in the future.
A reasonable balance is to be found between the collecting of geological material and the completion of research projects. The objective is that research be conducted so that it has the least possible impact on the geological layers.
Research is to contribute new knowledge. The objective is that research results be published in scientific journals, thus contributing to the knowledge accumulation within the research fields mentioned.
Research is to ensure wide impact through presentation to the public in general and to the users of Østsjællandss Museum in particular.
Østsjællandss Museum is to develop and participate in research collaboration with the right partners within the research fields mentioned.

6.1.4 Measures

Østsjællandss Museum emphasises the need to strengthen and conduct independent research within its fields of research and to participate in relevant research environments. This creates increased academic attention and forms the basis for scholarly well-founded and interesting dissemination.

The geology of limestone

Below follows an overview of Østsjællandss Museum's research activities in relation to Stevns Klint's geology in the coming years. All research projects are carried out in collaboration with relevant research institutions and most often have external funding.

It has not been possible to clarify the extent of future research projects on Stevns Klint's geology among other Danish and international researchers.

No.	Measure	Content	Time schedule	Responsibility
19	Injection of resources	Østsjælland's Museum needs to have resources injected to secure a research level that is applicable to World Heritage.	2016	Stevns Municipality
20	Paleoecology and deposit environments at Stevns Klint	Mapping and analysis of bank systems in blackboard chalk and paleoecological survey of the fauna in relation to deposit environments. In 2011, the Museum will publish a book about fossils from Stevns Klint based on the survey.	2011	Østsjælland's Museum University of Copenhagen
21	CT scan of fossils in the limestone	Study of the possibilities of using CT scanning on various fossils, both trace fossils and body fossils.	2010-15	Østsjælland's Museum in collaboration with the Institute of Forensic Medicine at University of Copenhagen and Lund University
22	The limestone's vertebrates	An overview of vertebrates.	2012-14	Østsjælland's Museum

The cultural history of limestone

Over the coming years, research and studies about the cultural history of limestone will focus on documentation of which parameters are decisive for the production of limestone. The starting point will be a documentation of physical facilities combined with ethnological studies, so that sufficient background knowledge is gathered as a basis for a definition of an actual research project. Research on the cultural history of limestone is handled by Østsjælland's Museum.

The Cold War

Østsjælland's Museum has entered into a collaboration agreement with the SAXO Institute at the University of Copenhagen on research into The Cold War and also has a collaboration agreement with Cold War Museum Langelandsfort. So far, collaboration has included the preparation of a research degree dissertation about the background for the construction of Stevnsfort. The good collaboration will continue in the coming years.

No.	Measure	Content	Time schedule	Responsibility
23-24	Limestone-related industrial enterprises	A study is to be carried out about limestone-related industrial enterprises in the area, including large enterprises in the limestone quarries of Boesdal, Holtug and Sigerslev Kalkbrud, with a view to shedding light on the enterprises' significance in relation to local business opportunities. The study also focuses on working conditions, goods distribution, product development and marketing.	2011-14	Østsjælland Museum
25	Quarrying at Stevns Klint	Documentation of quarries and facilities erected as a consequence of quarrying directly at Stevns Klint.	2012	Østsjælland Museum
26	Building stones of the Middle Ages	A number of scientific and historical studies of limestone construction materials used in large Medieval buildings in Denmark are to be conducted. The studies are to determine how the limestone was quarried and the socio-economic and clarify strategic perspectives in the use of limestone as a construction material. Conducted in collaboration with relevant museums and authorities.	2012-14	Østsjælland Museum
27	Houses made of limestone	An extended, publicly accessible database with information about limestone buildings in the area and the rest of the country will be prepared.	2011-14	Østsjælland Museum
28	Stevns Lighthouse	Study of the two listed lighthouses by Stevns Klint, made of construction materials from the cliff.	2010-11	Østsjælland Museum
29-32	Cold War Museum Stevnsfort	Documentation of the Cold War facility built directly into the rock behind Stevns Klint and of everyday life in the facility, including studies of conscription and military service, as well as civilian and military.	2011-2014	Østsjælland Museum

6.2 Dissemination

In coming years, there will be great focus on dissemination of Stevns Klint. With Østsjælland Museum as the driving force, the intention is to increase knowledge continually about geology and cultural history in relation to Stevns Klint. Dedicated work is necessary to achieve this, and this is already in progress.

6.2.1 Current situation

In geological circles, Stevns Klint is known across the world, and fragments of the cliff are exhibited at several foreign museums. However, to the general public, Stevns Klint is less well known, which may be due to limited communication.

Østsjællandss Museum is the primary communicator. One of Østsjællandss Museum's permanent tasks is to handle the Museum's communication about the geology and natural and cultural history along Stevns Klint. In connection with Stevns Klint's candidacy to be inscribed on UNESCO's World Heritage List, an agreement has been made between Stevns Municipality and Østsjællandss Museum according to which the Museum will handle presentation along Stevns Klint. In recent years, Østsjællandss Museum has experienced communication success by offering visitors experiences and unique stories in authentic environments, including at Cold War Museum Stevnsfort, Stevns Nature Centre and Geomuseum Faxe. Østsjællandss Museum has 35 guides at its disposal, distributed across Cold War Museum Stevnsfort, Stevns Museum and Stevns Nature Centre.

Today, presentation of Stevns Klint takes place at the different branches of Østsjællandss Museum, out by the cliff and on various media platforms.



Geological exhibition

Stevns Museum

Stevns Museum is a traditional regional museum with a permanent culture-historical exhibition. In 2011 and 2012, the Museum shows a special exhibition about Stevns Klint as a UNESCO World Heritage candidate.

One of the things Stevns Museum presents is the history of Stevns Klint – anything from the formation of the cliff and interesting fossils to the great mass extinction, culture-historical effects connected with the work at the cliff and the most recent research results.

Visitors can join guided tours within the following themes: Stevns Klint's geology, nature and cultural history.

Stevns Nature Centre

Stevns Nature Centre offers active nature experiences with particular focus on schools. The Nature Centre offers nature guidance, teaching, school service and guided tours about geology and the living nature along Stevns Klint. A well-equipped nature laboratory with appropriate field equipment makes it possible for school pupils and others to work with geology, flora and fauna as well as the Baltic Sea environment. Stevns Nature Centre has overnight accommodation facilities and offers school camps.

Flagbanken is Stevns Nature Centre's public offer. It has two small, open exhibitions about the area and geology. In 2010, a new exhibition opened about Stevns Klint's geology with fine fossils.

Cold War Museum Stevnsfort

The authentic military facility, Stevnsfort, forms the setting for Cold War Museum Stevnsfort's story about The Cold War and provides a unique opportunity to study Stevns Klint's geology close-up.

Cold War Museum Stevnsfort offers guided tours of the military facility – including in the 1.6 kilometres of underground passages – which provide visitors with insight into Stevnsfort's history during The Cold War. In addition, teaching is offered to school classes. More than 90 school classes visited Cold War Museum Stevnsfort in 2010. The Museum also offers guided tours where visitors are given an introduction to the geology of Stevns Klint based on the Fortress' underground passages.

Further to guided tours, information boards and exhibitions, Cold War Museum Stevnsfort has been successful in using mobile information solutions as the Museum has introduced a solution based on the iPod / iPhone platform (NOUS guide) with stories and films.

Along Stevns Klint

In selected spots along Stevns Klint, information boards have been set up to provide information about geology, nature and cultural history. Stevns Municipality and the Danish Nature Agency, respectively, are responsible for the information boards. This communication effort is currently not coordinated.

Østsjælland's Museum, Stevns Municipality and the Danish Nature Agency all offer public tours along Stevns Klint with a focus on geology, nature and cultural history.

Other dissemination

Østsjælland's Museum continually contributes to public knowledge about Stevns Klint and its history, e.g. through the production of books and pamphlets, lecture activities, articles in newspapers and magazines, and participation in radio and TV shows.

Furthermore, communication about Stevns Klint is found on a small scale on the websites of Østsjælland's Museum, Stevns Library and the Danish Nature Agency as well as on other websites.

6.2.2 Challenges

The challenges related to dissemination about Stevns Klint generally apply to dissemination activities, but as appears from the following, Østsjælland's Museum is well equipped to meet these challenges.

The challenges consist in:
Procuring funding for future dissemination initiatives about Stevns Klint.
Targeting communication at different groups of visitors.
Securing a sustainable visitors' pattern along Stevns Klint through the development of targeted communication and infrastructure measures.
Utilising modern communication platforms that will bring presentations alive and make them relevant.
Continually collecting and processing new knowledge about Stevns Klint, which can be included in the dissemination activities.

6.2.3 Objectives for dissemination

Østsjælland's Museum works purposefully on the development of communication about Stevns Klint.

Dissemination objectives
Based on the Museum's own experience with dissemination and thorough local knowledge about the nature, culture and geology of Stevns Klint, it is Østsjælland's Museum's goal to create presentation offers of high quality and to procure new knowledge and make it accessible to visitors.
Visitors are to be given the right information in the right form at the right place. The objective is to make the stories come alive and be relevant based on the authentic localities.
Communication must be adapted to the level required by the individual visitor. The goal is that visitors should be able to choose between basic information and detailed material about Stevns Klint.
Presentations should take place both in a traditional manner and via modern communication platforms. The goal is that presentations be varied and involve the visitors.
Dissemination should be sustainable in relation to safeguarding the outstanding value.

6.2.4 Measures

Østsjælland's Museum has launched a large-scale focus on dissemination. The objective of the Stevns Klint+ project is to create professional communication of a quality that corresponds to Stevns Klint's status as a potential UNESCO World Heritage Site. Dissemination matches a modern audience's requirements on interactive offers, varying activities and unique stories. The effort is to contribute to giving enriching quality experiences, which will encourage visitors to stay in and move around the authentic environments along Stevns Klint.

Additionally, Østsjælland's Museum focuses on developing school services aimed at lower and upper secondary school pupils as a supplement to the existing offers to schools.

No.	Measure	Content	Time schedule	Responsibility
33	Injection of resources	Østsjælland's Museum needs to have resources injected to secure a communication level that is applicable to World Heritage.	2012-16	Stevns Municipality
34	Stevns Klint+ virtual knowledge bank	A virtual knowledge bank is to be established in which data from other knowledge providers are gathered. The knowledge bank will form the basis for the digital communication platforms mentioned below.	2011-12	Østsjælland's Museum
35	Stevns Klint+ web introduction	The web introduction will serve as inspiration and preparation for a visit to Stevns Klint. The content is to be presented in a clear, dynamic form with the users' needs and interests as the central focus. The introduction will also serve as an entrance to other information about Stevns Klint on the internet.	2011	Østsjælland's Museum
36	Stevns Klint+ smartphones	Smartphones make it possible to give visitors the right information in the right form at the right place. This is to support the experience of authentic environments and inspire people to investigate the area. Knowledge and movement along Stevns Klint are to be united via the mobile platform in a playful and intuitive manner that will stir interest and motivate visitors to move further along. Visitors can actively choose an appropriate information level in the relevant place along Stevns Klint within the individual themes: geology, nature, cultural history and The Cold War.	2011-12	Østsjælland's Museum
37	Stevns Klint+ digital info boards	Digital info boards will be erected in select places with a view to communicating complex stories and themes in an accessible and involving way.	2012	Østsjælland's Museum
38	Stevns Klint+ signage	Signage is a classical and efficient way of communicating knowledge. Signage is particularly aimed at the visitors who do not want presentations via mobile platforms.	2012	Østsjælland's Museum in collaboration with Stevns Municipality and the Danish Nature Agency
39	Stevns Klint+ narrative material	Eight campaigns are planned with the objective of collecting narrative material, such as memories, photos, films etc. The campaigns are organised in close connection with Østsjælland's Museum's research and communication, especially within the field of cultural history.	2011-12	Østsjælland's Museum

No.	Measure	Content	Time schedule	Responsibility
40-41	Stevns Nature Centre – school service	<p>The existing teaching offer aimed at pupils from the lower and upper secondary school level is to be developed with a view to giving pupils insight into the development of Earth and life. Courses will also be developed at Stevnsfort with the possibility of interdisciplinary courses.</p> <p>The Ministry of Education's requirements on content will form the basis for teaching activities.</p>	2011-12	Østsjællands Museum
42	Stevns Lighthouse	A frame/framework exhibition will be prepared, and information signs will be erected.	2011	Østsjællands Museum in collaboration with Stevns Municipality
43-44	Stevns Museum – welcome exhibition	<p>A visitors' centre will be established in connection with Stevns Museum, which is to direct visitors to the different visitors' offers along Stevns Klint.</p> <p>The visitors' centre will include an exhibition that introduces the cliff's main themes and provides detailed information about the geology and cultural history of limestone.</p>	Awaiting funding	Østsjællands Museum
45	Presentation video	A new presentation video is to be made about Stevns Klint as a world-class geological locality.	2013	Østsjællands Museum
46	Book on fossils from Stevns Klint, Møn and Northern Jutland	<p>Publication of book on fossils from Stevns Klint, Møn and Northern Jutland.</p> <p>The book is written by amateur geologists Alice and Leif Rasmussen from Faxe and Thomas Hansen from Østsjællands Museum, and it is a richly illustrated atlas with several hundred images of all of the most common, but also a great deal of the less common, fossils that can be found in the chalk and limestone.</p>	2011	Østsjællands Museum
47	General information about Stevns Klint	In future, there will be a continual focus on working with the media, including feature stories for TV, radio, newspapers and the internet.	2010-	Østsjællands Museum

7 Sustainable Tourism

Geology and the living nature are decisive for tourism at Stevns Klint. It is therefore a basic prerequisite for tourism that the geological values in the nominated area be protected and conserved. Safeguarding sustainable tourism is also considered crucial for a well-preserved outstanding universal value. It is important to ensure that visitors have the possibility of experiencing Stevns Klint and the area's values. In other words, the interplay between the area's outstanding geological values and tourism is of great significance when it comes to fulfilling the Management Plan's vision and objectives.

The involved players at Stevns wish to promote knowledge of the nominated area through sustainable tourism in order to provide eventful experiences for visitors without compromising on the protection of Stevns Klint's geological values and the area's other natural and cultural values. This wish converges with UNESCO's view that sustainable tourism is the only way to guarantee the safekeeping of the world's natural and cultural heritage.¹



View

What is sustainable tourism?

The concept 'sustainable tourism' normally considers three aspects of sustainability:

Nature's sustainability is the load capacity of the natural foundation. This means that due consideration must be given to Stevns Klint and the other natural values in the area with a view to conserving the area's integrity, so that present and future generations of visitors can experience the natural values.

Sociocultural sustainability is consideration for the well-being of the local community. This implies that the social and cultural integrity of the local community must be respected and protected against the impact of tourism to the necessary extent.

Financial sustainability is a reasonable balance between potential social and business economic gains and investments. As far as possible, tourism should contribute to creating financial development and job opportunities at Stevns.

¹ UNESCO (2002): *Managing Tourism at World Heritage Sites: a Practical Manual for World Heritage Site Managers*, World Heritage Manuals #1, UNESCO World Heritage Centre, France.

Apart from protecting and presenting Stevns Klint, sustainable tourism aims at presenting the area's other valuable cultural environments and at contributing to the local community's financial and socio-cultural development. It should be stressed that nature's sustainability takes priority over financial and sociocultural sustainability. After all, without a protected and well-conserved Stevns Klint, there would be no foundation on which to develop World Heritage tourism. However, this does not necessarily mean that there is a conflict between the different aspects of sustainable tourism. By working deliberately and purposefully with sustainable tourism, it is the intention to create new synergy between the different aspects so that they have a mutually positive effect on each other.

Tourism at Stevns has successively become more and more sustainable over the last decade, and today, Stevns Tourist Office, Østsjælland's Museum and Stevns Municipality collaborate with a focus on creating sustainable nature tourism – not only along Stevns Klint, but also throughout the Municipality. The good and close collaboration between the main players and the administration is particularly important in order to achieve sustainable tourism.

Surveys of tourism at Stevns in 2010 have shown that visitors are mainly Danish, German and Swedish tourists.² The visitors, who are primarily aged between 35 and 67, mainly visit to experience Stevns Klint and the nature of Stevns as a whole. The greatest tourist attraction is Stevns Klint. This includes all of Stevns Klint, and Højerup is the area that receives most visits. Other popular sites of interest are Rødvig, Cold War Museum Stevnsfort, Store Heddinge and Stevns Museum. Store Heddinge is the only of these sites of interest that is not located immediately adjacent to the nominated area.³ The many visitors' sites along Stevns Klint facilitate a variety of ways of experiencing the geological value. They also increase the sustainability of the area, because visitors are spread across a larger area. It is part of the planning to ensure that the sustainability of the individual visitor's site is not exceeded.

7.1 Visitors' sites and activities

Stevns Klint's attraction value to visitors lies in the limestone's untamed and visual beauty, the constant changes in the appearance of the cliff with new exposures, the interesting stories about Stevns Klint and Earth's development, the biotopes and the culture-historical remnants that bear witness to centuries of life along Stevns Klint.

Every year, some 100,000 tourists visit Stevns Klint, which means that Stevns Klint is the 8th most visited tourist attraction in Region Zealand. Additionally, many local citizens enjoy the area along Stevns Klint in connection with various open-air activities.

Stevns Klint and the other sites of interest in the buffer zones are not yet great tourist attractions despite the obvious values and the increasing number of visitors, as the sites unique character and contexts are still unknown to most people. Thus, there is a great potential for development of the area's qualities, e.g. by linking the sites of interest better, providing the necessary facilities for visitors and marketing Stevns Klint as an outstanding value with several coherent elements.

The many sites of interest along Stevns Klint make it possible to maintain sustainable tourism, also with increasing numbers of visitors, as they make it possible to distribute the visitors' load along the cliff. The sites of interest provide different experiences of the outstanding value.

7.1.1 Current situation

The application to have Stevns Klint inscribed on UNESCO's World Heritage List is based on the outstanding geological value. Stevns Klint can be experienced in various ways: from land, from the sea, underground and from the air. Højerup constitutes the central visitors' site for the area's outstanding value. Along the cliff, there are a number of sites of interest, which allow access to the geological values. Many

² VisitDenmark (2011): *Turismens økonomiske betydning i Region Sjælland (Tourism's Economic Significance in Region Zealand)*, Copenhagen, p. 33.

³ Stevns Tourist Association and Stevns Municipality (2010): *Turistundersøgelse Stevns Kommune 2010 (Tourist Survey Stevns Municipality)*, Stevns.

of these localities also contain culture-historical environments related to the special cultural history that has emerged because of Stevns Klint's geology and topography. Thus, tourists experience that there are more attractions within one visitor's site.

Below follows an account of the current situation for visitors' sites and activities along Stevns Klint.

Højerup

Højerup is the classical, but also central place from which to experience Stevns Klint. At Højerup, the cliff's characteristic stratification is visible from a number of vantage points along the cliff edge. Steps lead down to the beach from which it is possible to see the characteristic structure and to get close to both the layers of chalk and limestone and the actual boundary layers.

With approx. 100,000 visitors per year, Højerup currently serves as the centre for visitors to the nominated area. The area's current parking capacity is adequate, but close to being used to the full at peak times. Work is therefore in progress to ensure better parking conditions.

Stevns Museum is located in Højerup. At the Museum, the geological history of Stevns Klint is presented – including information that ranges from the cliff's formation and interesting fossils to the great mass extinction. Furthermore, culture-historical objects related to the work at the cliff are displayed along with the latest research results. Stevns Museum currently has 5-6,000 annual visitors. The Museum is well suited for disabled people and has a museum shop.

Højerup as a whole presents Stevns Klint by connecting the area's cultural and natural history. At Højerup, it is also possible to see culture-historical traces in Stevns Klint. Højerup Old Church is a nationally known and listed monument, located dramatically on the very edge of the cliff. The church was con-



Højerup Old Church

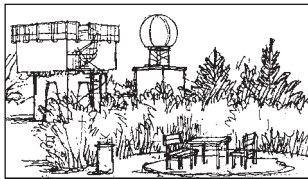
Map of places to visit



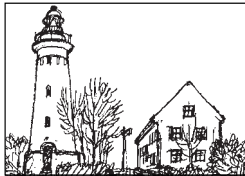
Bøgeskov Havn



Holtug Kridtbrud



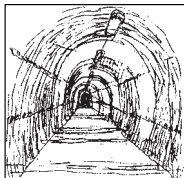
Stevns Naturcenter Flagbanken



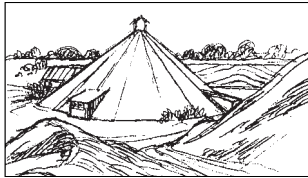
Stevns Fyr



Højerup Gl. Kirke



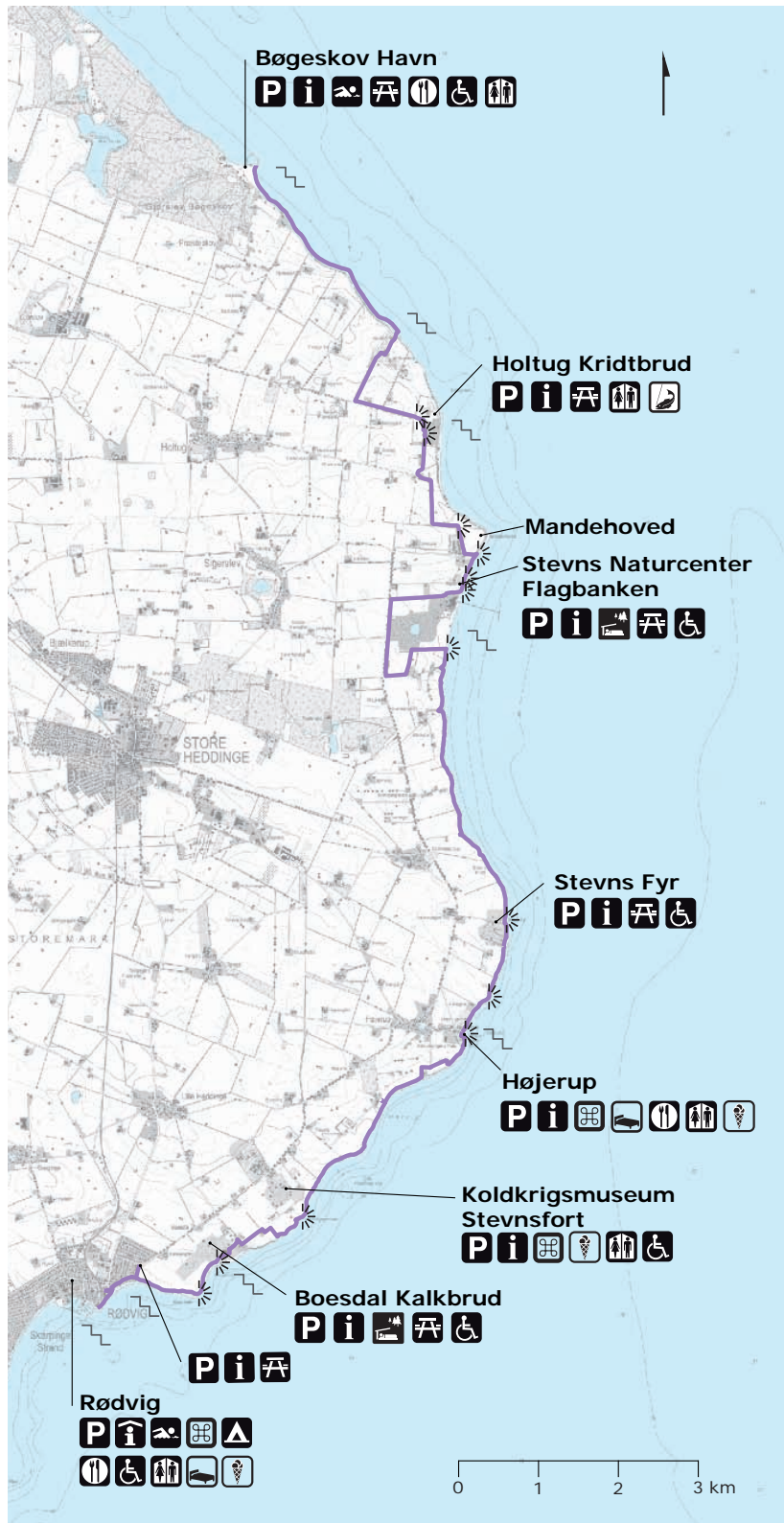
Koldkrigsmuseum Stevnsfort



Boesdal Kalkbrud



Rødvig



Trampesti Access to the beach / sea view point

structed of limestone ashlar c. 1250-1300. In 1928, the church choir tumbled into the sea in a huge cliff slide.⁴ Since then, the coast beneath the church has been secured so that Højerup Old Church now contributes to a spectacular and scenic experience of the forces of nature and the natural coastal erosion.

Trampestien

One of the best ways of experiencing Stevns Klint and its outstanding geological value is to walk along the footpath Trampestien, which stretches 20 kilometres all the way from Rødvig to Bøgeskov, linking the cliff's sites of interest. The footpath is easily accessible with public car parks in several places along Stevns Klint. Currently, the footpath is not well suited for walking impaired people or wheelchair users, but there are plans to have the path made accessible for disabled people. One disadvantage of the path is that transport opportunities between Rødvig and Bøgeskov are poor.

Trampestien runs along the edge of Stevns Klint, on the beach and along some stretches a bit inland. Along the route, there are several good vantage points from the edge of Stevns Klint, e.g. by Boesdal, Brudesengen by Cold War Museum Stevnsfort, Højerup, Bråten, Flagbanken and Holtug Kridtbrud. Similarly, there are fine opportunities for reaching the beach to study the stratification close-up, e.g. by Rødvig, Boesdal, Højerup, Holtug Kridtbrud and Bøgeskov.

Trampestien is an excellent example of how nature's sustainability and sociocultural sustainability can be safeguarded at the same time. The footpath is clearly marked, and by the access points, information boards provide information about Stevns Klint and regulations for traffic. This helps ensure that the nature is worn as little as possible when visitors walk along the path. A voluntary agreement about the footpath between plot owners and Stevns Municipality make it possible for plot owners to influence management of the path, and at the same time, the agreement ensures that the general public can walk freely along Stevns Klint. On the stretch between Rødvig and Boesdal Kalkbrud, Trampestien is listed.⁵ The conservation authorities have not considered it necessary to list the rest of the footpath, as the voluntary agreement works according to its purpose. Today, Stevns Municipality is responsible for maintenance of Trampestien.

Boesdal Kalkbrud

Boesdal Kalkbrud is an abandoned limestone quarry less than two kilometres from Rødvig. Today, Boesdal is laid out for public recreational purposes. The south-facing cliff profile is part of the nominated area, as the stratification inland is very evident here and can be studied close-up. Boesdal Kalkbrud also provides access to the beach, from which the clear stratification can be seen. The coastline between Boesdal and Rødvig is among the best places for experiencing the cliff's outstanding values, as the boundary layers are very easily accessible and the great banks of bryozoan limestone are very clear. There are also good chances of finding fossils in fallen blocks on the stretch of coast between Boesdal and Rødvig. Boesdal Kalkbrud has fine culture-historical remnants from the time when the quarry was in operation, including the 3,000 m² 25 metres high cone-shaped warehouse, a barn and two old limestone ovens.

The area is used actively by local citizens and associations for recreational activities. For instance, Boesdal is used for celebrating Constitution Day events, Pentecost services, arts exhibitions and workshops, concerts, dance and theatre shows and role-plays. Furthermore, the old limestone quarry is used for various open-air activities such as picnics, jogging, walking dogs on leash, climbing, abseiling and paragliding. The area is also a starting point for many divers who wish to explore the waters off Stevns Klint. Current activities do not constitute any risk to the geological values.

Boesdal Kalkbrud is easily accessible, and there is a public car park in connection with the area, where information boards provide details about the quarry and its history.

⁴ Danish Heritage Agency (2002): *Stevns Kommuneatlas, Byer og bygninger 2002 (Stevns Munipal Atlas, Towns and Buildings)*, Ministry of Culture, Copenhagen, p. 26.

⁵ Ruling from the Danish National Trust 28 June 1957 about conservation of *Stevns Klint Sti (Stevns Klint Footpath)*.

Boesdal Kalkbrud is owned by Stevns Municipality. The association Foreningen Boesdal, which consists of local forces, has an operating agreement with Stevns Municipality about handling operation, development and administration of the area. A nature preservation plan for the area in combination with regulations for traffic ensure that due attention is given to maintaining nature's sustainability in relation to activities in the area.⁶ Communication about the area's geology is carried out in collaboration with Østsjælland's Museum.

Cold War Museum Stevnsfort

Cold War Museum Stevnsfort consists of 1.6 kilometres of underground passages, carved out of the limestone from the surface to a depth of about one metre above sea level. The underground passages form part of the nominated area, as it is possible to see and touch Stevns Klint's geological stratification in three dimensions here. The outstanding geology is presented at the fort via guided tours and an exhibition, which contains a model of the limestone banks and shows both the limestone formation and the flint formation.

The cultural environment around Stevnsfort also includes some buildings above ground and an air defence facility, which today combine to make up Cold War Museum Stevnsfort.



The underground passages

Cold War Museum Stevnsfort appears as a complete and authentic military facility from The Cold War. Cold War Museum Stevnsfort is yet another excellent example of the local anchoring along Stevns Klint. The Museum was created with very active support from dedicated local people. Today, three groups of volunteers are associated with Cold War Museum Stevnsfort, where they help look after the area's values. A nature preservation plan has been drawn up for the area.

Stevns Municipality owns the area, while Østsjælland's Museum runs Cold War Museum Stevnsfort as well as the culture-historical and the geological presentation. On a few occasions, the Museum has offered visitors helicopter rides along Stevns Klint.

Holtug Kridtbrud

The abandoned chalk quarry Holtug Kridtbrud is a good place to study the outstanding values of Stevns' geology, and chalk, limestone and boundary layers are all visible. Facilities used in connection with the former quarry activities have been removed and the area now stands as a nature area. Because of the area's special habitat, flora and fauna, Holtug Kridtbrud is included in the European nature protection network Natura 2000. Among the rare species found here are Great Crested Newt, Sand Lizard, Adder and Knapweed Broomrape. From the quarry, there is access to the beach.

The area is in a remote location and receives less visitors than the other visitors' sites along the cliff. Therefore, the area is a popular spot for nature and open-air people who wish to look at geology and study rare animals and plants. The area is also used for presentations for schoolchildren. Furthermore, the area is a popular place to fish for sea trout and garfish from the beach.

⁶ Stevns Municipality (2007): *Local Plan 47 for Boesdal Kalkbrud*, Dept. of Technology & Environment. See <http://www.stevnskom.dk/Lokalplaner/47.pdf>.

Nature's sustainability is a focal point in Holtug Kridtbrud, and specific regulations apply to the area to protect the natural values.

The Danish Nature Agency owns Holtug Kridtbrud.

Stevns Nature Centre – Flagbanken and Mandehoved

Located at 40 metres above sea level, Flagbanken and Mandehoved are among the highest places along Stevns Klint. The area offers views from the cliff edge from which to gain a good impression of the cliff's characteristic structure with the lower soft chalk and the upper hard limestone separated by the boundary layers.

The area constitutes a cultural environment from The Cold War, where a missile battery with radar surveillance was set up on Flagbanken, while Mandehoved served as barracks. Today, the area contains Stevns Nature Centre.

The Nature Centre is an important support point for the experience of Stevns Klint, as geology is taught and presented here, and active nature experiences are offered. The well-equipped nature laboratory contains field equipment for work with geology, flora, fauna and the Baltic Sea environment. Stevns Nature Centre has overnight accommodation facilities and offers school camps, teaching and organised tours with a nature guide. Activities are primarily aimed at groups. Some 5,000 people visit the Nature Centre each year.

Flagbanken is Stevns Nature Centre's public offer. In the autumn, Flagbanken is one of Denmark's best bird migration localities, and the area features a bird observation tower. A small pavilion offers small, open exhibitions about the area and its geology, including an exhibition of fine fossils found by Stevns Klint.⁷

Stevns Nature Centre is owned by Stevns Municipality and run by Østsjælland Museum.

Stevns Lighthouse, Stevns Fyr

Stevns Lighthouse is located to the immediate north of Højerup on the highest point of Stevns Klint – 41 metres above sea level. Stevns Lighthouse is laid out as a recreational area with a variety of open-air activities.⁸

Stevns Lighthouse consists of two listed lighthouses and a lighthouse keeper's house. In connection to the area, there is a cultural environment from The Cold War. The two lighthouses and the lighthouse keeper's house have a very special value as building cultural heritage, and today, the buildings are listed.⁹

The geological core value is visible from the top of the tall lighthouse and along the cliff edge to the north and south of the lighthouse. From the top of the lighthouse, the visitor has a particularly good overview of the landscape and the entire span of the cliff. The geological history and the area's nature are presented in a permanent exhibition as well as on signs in the area. The area's cultural history is presented in the lighthouse keeper's house in the form of an exhibition concerning technical data, daily life in the lighthouse, shipwrecks, rescue service and surveillance of the sea. Cultural events and health promoting activities are held regularly in the area.

The area is accessible to the public and has good parking facilities. Wheel chair users are able to get right to the edge of Stevns Klint in the area.

⁷ Stevns Nature Centre (2010): *Oplev Stevns Klint (Experience Stevns Klint)*, Østsjælland Museum, p. 14.

⁸ Stevns Municipality (2006): *Local Plan 73, Stevns Lighthouse*, Dept. of Technology & Environment, p. 5. See <http://www.stevnskom.dk/Lokalplaner/Lok73E.pdf>.

⁹ Stevns Municipality (2006): *Local Plan 73, Stevns Lighthouse*, Dept. of Technology & Environment, p. 15. See <http://www.stevnskom.dk/Lokalplaner/Lok73E.pdf>.



Stevns lighthouse and Squadron 543

The Danish Nature Agency owns Stevns Lighthouse, and Stevns Municipality leases the area for recreational purposes. A nature preservation plan has been elaborated for the area, and several active, local groups of volunteers contribute to the development of the area. In this way, consideration is given both to nature and to the interests of the local community in the area.

Rødvig Havn and Bøgeskov Havn

The harbours Rødvig Havn and Bøgeskov Havn are located at the southern and northern ends of Stevns Klint, respectively. Rødvig Havn is located outside the buffer zone, while Bøgeskov Havn is a part of the functional buffer zone.

Both harbours are good starting points for excursions to Stevns Klint, whether visitors choose to sail along the cliff or walk along the beach. The stretch from Rødvig is particularly valuable to the experience of the geological core value, as the boundary layers can be experienced close-up here.

Sailing along Stevns Klint makes it possible to study the development of the layers along the cliff where the boundary layers are found at varying heights above the sea. From the sea, you also get a good impression of the shape of the limestone banks.

Rødvig is the centre for tourism in Stevns with good infrastructure, see Chapter 8. Rødvig Havn is a popular marina and a natural gathering point for citizens and visitors in Rødvig. During the summer months, visitors are occasionally offered the opportunity to join a boat trip along Stevns Klint. Stevns Tourist Office has an office by the harbour.

7.1.2 Challenges

Tourism along Stevns Klint currently has potential for further development. This presents a number of challenges to the individual visitors' sites and to Stevns Klint as a whole.



Rødvig

The challenges consist in:
Safeguarding the prerequisites of tourism – Stevns Klint, nature and the geological history – and anchoring them in dissemination.
Accommodating the strain on nature's sustainability by directing visitors to the localities that have been adapted and are able to receive more visitors.
Coordinating the interests of local citizens and plot owners with the needs related to tourism and recreational activities along Stevns Klint.
Balancing ambitions with needs and opportunities in the local community.
Balancing information and marketing of Stevns Klint with the visitors' capacity.
Ensuring high-quality, homogenous communication of Stevns Klint.
Conserving the unique building culture along Stevns Klint.
Attracting more visitors to Stevns Klint.
Procuring funding for investments.

7.1.3 Objectives for visitors' sites

The existing conditions for tourism in the area along Stevns Klint imply that there is both a large potential for development of tourism and good opportunities for maintaining and promoting sustainable tourism in Stevns.

Objectives for visitors' sites
Communication of the core tourism values is to be strengthened. Development of the main attractions is to take place via preservation and strengthening of presentations.
Visitors' sites along Stevns Klint are to be developed without compromising on the natural or cultural values. The objective is that activities for visitors are to place the least possible strain on Stevns Klint and the other values.
Visitors' sites along Stevns Klint and related infrastructure are to be improved in collaboration between Stevns Municipality, the people responsible for operation and development at the visitors' sites, plot owners and local residents. The objective is to create modern services and facilities that are dimensioned to meet the needs of different groups of visitors with due consideration for the area's outstanding universal value.
The visitors' sites along Stevns Klint are to serve as meeting places for the local community and for visitors. The objective is that World Heritage and everyday life are in harmony.
Communication of Stevns Klint's natural and historical values is to be further developed and continually adapted to the visitors, including to an international audience.

7.1.4 Measures

In order to meet the challenges and fulfil the listed objectives, the involved players are launching a number of measures. Measures related to the infrastructure of the visitors' sites are introduced in Chapter 8.2.4.

The tourism-related measures focus on strengthening the communication of the outstanding universal value. Communication constitutes a significant part of the protection of the nominated value. The measures are also to ensure the development of sustainable tourism, among other things through optimisation of the visitors' facilities by a number of visitors' sites along the cliff.

No.	Measure	Content	Time schedule	Responsibility
48	Visitors' centre	A new visitors' centre for Stevns Klint as a World Heritage Site is to be a centre for visitors and a focal point for communication of the outstanding value through presentations, guided tours, exhibitions, teaching and research. Dissemination is a part of the conservation strategy.	Awaiting funding	Østsjælland's Museum Stevns Municipality
49	Protection and development of the classic visitors' site Højerup	Højerup is the classic visitors' site. A vision and strategy is to be prepared for the further development of the area Højeruplund in order to ensure that the area is sustainable when tourism increases, and to strengthen the conservation and dissemination of the area's outstanding universal value.	2012	The society Selskabet Højeruplund Østsjælland's Museum
50	On-site presentation	Presentation of the outstanding universal value is to be strengthened via digital communication on mobile platforms.	2011-12	Østsjælland's Museum in collaboration with a number of external partners

No.	Measure	Content	Time schedule	Responsibility
51	Guided boat trips	The possibility of experiencing the outstanding universal value is to be strengthened through the establishment of guided boat trips. Work is in progress to prepare a financially sustainable structure.	2012	Stevns Municipality Østsjælland Museum
52	Boesdal – protection and development of the area	Boesdal is a part of the nominated area and a central visitors' site and recreational area. Nature preservation of the area is in progress as are maintenance and extension of facilities for visitors with a focus on sustainability and accessibility to the nominated area.	2011-16	The association Foreningen Boesdal
53-56	Cold War Museum Stevnsfort – listing of the area	The passages in Stevnsfort form part of the nominated area. Initiatives have been launched to have Stevnsfort listed with a view to safeguarding the authentic cultural environment and a close regulation of the monument's appearance and use. Listing would also include protection of the outstanding universal value that can be experienced in the underground passages. Further development of the Museum with newbuild will be carried out with due respect for the nominated value.	2012	Cold War Museum Stevnsfort Østsjælland Museum
57	Architectural policy	Stevns has a special building culture, which is based on Stevns Klint. A process has been initiated during which an architectural policy will be developed with the objective of describing the building culture and character of all villages and towns in Stevns Municipality. Thus, an architectural policy will strengthen conservation and dissemination of the special cultural heritage that is linked directly to the geology of Stevns Klint.	2011-20	Stevns Municipality
58-59	Stevns Lighthouse, Stevns Fyr	Stevns Lighthouse is a visitors' site along the cliff. The area's presentation and visitors' facilities are to be developed with a focus on the nominated area's overall sustainability and with due consideration for the outstanding universal value and conservation of the authentic cultural environment. Inclusion of citizens is an important part of the process.	2011-12	Stevns Municipality Østsjælland Museum
60	School service	As mentioned in Chapter 6.2.4, further development of the existing teaching offer is to be aimed at the lower and upper secondary school level. Interdisciplinary courses are to be developed, and teaching is to take its starting point in the Ministry of Education's requirements on content.	2011	Stevns Nature Centre Østsjælland Museum Cold War Museum Stevnsfort

7.2 Service for visitors

The competition between tourist destinations is great, and this poses demands both on marketing of Stevns Klint and on the entire organisation of tourism in Stevns. It is therefore a prerequisite for attracting visitors to Stevns Klint and retaining them that the industry has a strong organisation and is able to offer modern high-quality services to visitors.

7.2.1 Current situation

Currently, the joint marketing and sales organisation for Stevns is handled by Stevns Tourist Office, which provides services for the tourists via the Office's website, the tourist office in Rødvig and the Stevns Catalogue. Stevns Klint is also marketed via the website of VisitDenmark and via Guide Denmark.

Østsjælland's Museum markets Stevns Klint through national and international media coverage of Stevns Klint, as described in Chapter 6.2.1.

Stevns has a varied offer of overnight accommodation options. Within the mainland buffer zone, there are a number of bed & breakfast places. Other overnight accommodation options are located outside the buffer zone – primarily in and around Rødvig and by Strøby Ladeplads. Visitors prefer to stay in rented holiday homes or on caravan sites.¹⁰

As mentioned in Chapter 7.1.1, boat trips are occasionally organised for visitors along Stevns Klint, the starting point being in Rødvig Havn. However, this is currently not a regular offer.

Østsjælland's Museum has 35 professional tourist guides at its disposal, distributed across Cold War Museum Stevnsfort, Stevns Museum and Stevns Nature Centre. The guided tours deal with Stevns Klint's geology and the area's other natural and culture-historical values.

Tourism accounts for almost 200 jobs in Stevns Municipality, and the total turnover in 2008 amounted to 155 million Danish kroner.¹¹

There are no large tour operators in the area.

7.2.2 Challenges

Today, the tourist industries at Stevns face organisational and service-related challenges.

The challenges consist in:
Developing new tourism offers in relation to Stevns Klint with due regard for nature's values and the interests of the local people.
Intensifying collaboration between the different players in the tourist, hotel and restaurant businesses.
Identifying target groups and developing interesting offers and services for visitors.
Joining the tourist attractions along Stevns Klint better together.
Strengthening product development.

¹⁰ East Denmark Tourism (2011): *Overnatnings- og attraktionsstatistik for Region Sjælland (Overnight Accommodation and Sites of Interest Statistics)*, Naestved, and Stevns Tourist Association and Stevns Municipality (2010): *Turistundersøgelse Stevns Kommune 2010 (Tourist Survey Stevns Municipality 2010)*, Stevns.

¹¹ VisitDenmark (2011): *Overnatnings- og attraktionsstatistik for Region Sjælland (Overnight Accommodation and Sites of Interest Statistics for Region Zealand)*, Copenhagen.

7.2.3 Objectives for tourism

As mentioned earlier, tourism along Stevns Klint is based on a sustainable foundation. This is reflected in the tourism objectives.

Objectives for tourism
Stevns Klint is to be developed to become an internationally known tourist attraction. The objective is to be achieved successively. By 2016, Stevns Klint will be known as a UNESCO World Heritage Site throughout the Nordic countries, Germany and the Benelux countries. By 2026, knowledge of Stevns Klint has spread across the globe.
Stevns Klint is to be a well-known locality for nature and cultural tourism. The objective is to conserve and further develop tourism on a sustainable foundation.
Development and marketing of Stevns Klint is to be targeted at nature tourism. The objective is to strengthen Stevns Tourist Office with a view to fortifying the joint marketing and development of Stevns Klint. The means to meeting the objective is active collaboration between the different players.
Guided tours and digital offers along Stevns Klint are to be promoted. The objective is to communicate knowledge about the outstanding universal value of the cliff's stratification.

7.2.4 Measures

In order to meet the challenges and fulfil the listed objectives, the involved players are launching a number of measures.

No.	Measure	Content	Time schedule	Responsibility
61	Strategy for Tourism	Strategy for Tourism in Stevns is a plan that is to outline how tourism is concretely to be promoted on a sustainable foundation, and how the sites of interest are to be linked together.	2012	Stevns Municipality Stevns Tourist Association Østsjælland Museum
62	Survey of tourism	Stevns Tourist Association conducted a survey of tourism at Stevns in 2010. The survey provided concrete knowledge about visitors, services, information and sites of interest. New surveys are to be carried out every two years.	Every two years	Stevns Tourist Association in collaboration with Stevns Municipality
63	Stevns Tourist Office	Stevns Tourist Office is to be strengthened through organisational development and the injection of resources and competences – including through closer collaboration with Stevns Municipality.	2013 Awaiting funding	Stevns Tourist Association Stevns Municipality

No.	Measure	Content	Time schedule	Responsibility
64	Marketing	Marketing of Stevns Klint is to be targeted at Denmark, the Nordic countries, Germany and the Benelux countries.	2012-16 Awaiting funding	Stevns Tourist Association
65	Theme day for the tourist industry	An annual theme day is to be organised for players in the tourist industry at Stevns.	2011 and then every year	Stevns Municipality Stevns Tourist Association
66	Product development	Product development is to create varied and eventful experiences for visitors based on a sustainable foundation.	Continually	Østsjælland Museum Stevns Tourist Office Stevns Municipality
67	Education	Education, supplementary and further training of guides for the area will take place on a continual basis.	Continually	Østsjælland Museum
68	Facilities	The facilities by the visitors' sites are to be maintained continually and improved as needed, so that they correspond to the visitors' needs and expectations.	Continually	Stevns Municipality Østsjælland Museum Højeruplund



lime piece on the beach

8 Infrastructure

Good transport options and an efficient infrastructure to Stevns Klint are a prerequisite for ensuring good accessibility to the nominated area and the other values in the buffer zones. Stevns Municipality would like traffic to flow in an appropriate way, i.e. so that traffic to and along Stevns Klint causes least possible hassle to the nominated area, nature and the local community.

8.1 Modes of transport

Stevns Klint can be reached in various ways. It is also generally easy to move between the visitors' sites in the area.

Below follows an account of the possible modes of transport.

8.1.1 Car traffic

The car is the preferred mode of transport to and along Stevns Klint – both for visitors and for local residents. As for visitors, the latest tourist survey showed that about 85% of all visitors come to Stevns in private car or by bus.¹

8.1.2 Bus traffic

Bus traffic can be divided into private and public busses. During the summer, private tour operators arrange bus trips to Stevns Klint, primarily to Højerup, Rødvig and Cold War Museum Stevnsfort.

8.1.3 Train traffic

Stevns can be reached easily by train. Train connections on the stretches between Copenhagen and Køge, Roskilde and Køge, and Næstved and Køge, respectively, are all good, and from Køge, the Østbanen line offers regular departures to Store Heddinge and Rødvig at Stevns.

8.1.4 Yachting traffic

Stevns is a popular place for yachtsmen to moor. Rødvig is one of the region's large visitors' harbours. Yachtsmen often stay in the harbour a couple of days. Bøgeskov Havn is a smaller marina. The two harbours are at either end of Stevns Klint.

8.1.5 Bicycle traffic

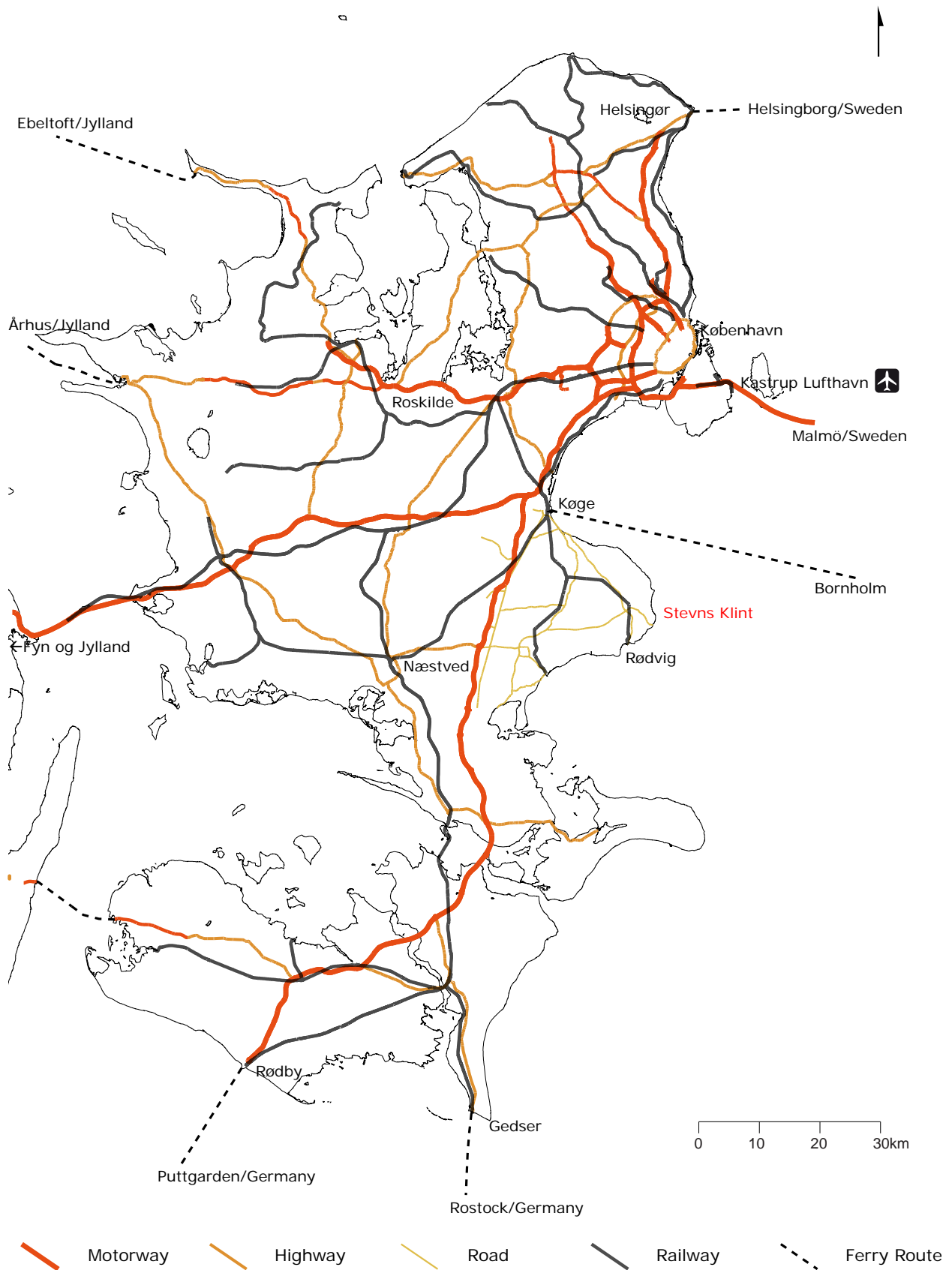
Bicycle traffic is advancing at Stevns, and in recent years, a number of bike paths have been established. Cycling to Stevns is popular, which is partly because Stevns is on the Berlin-Copenhagen bicycle route.

8.1.6 Walking

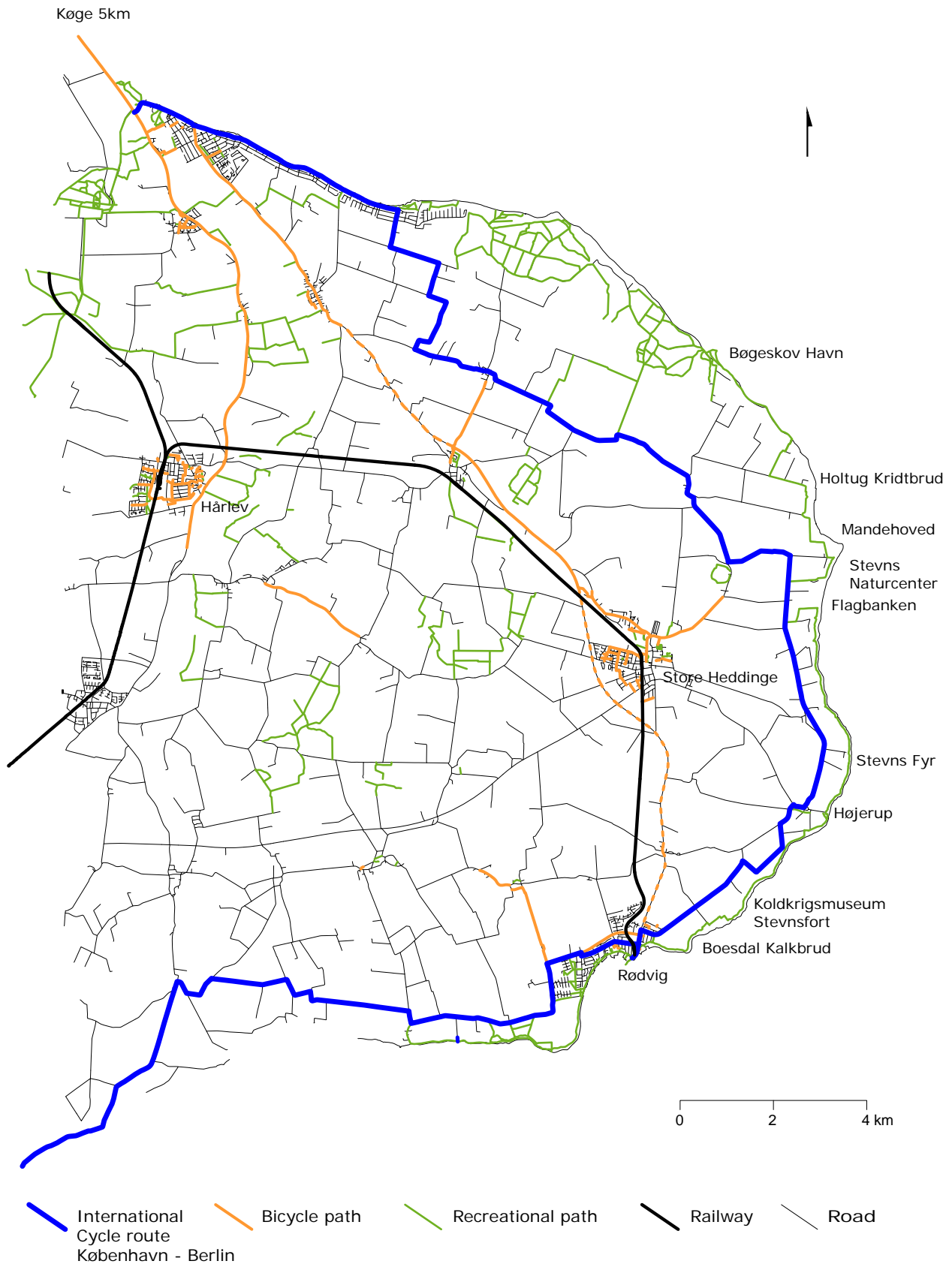
As mentioned in Chapter 7.1.1, there is a footpath along Stevns Klint, which is popular for local and visiting ramblers. Practically all visitors use part of the footpath during their stay at Stevns. The footpath has a number of vantage points and steps down to Stevns Klint, from which visitors can experience the nominated area. A number of *tænkebænke* (benches for moments of reflection) have been set up by the best vantage points. Furthermore, the footpath passes by all the visitors' sites in the buffer zone.

¹ Stevns Tourist Office and Stevns Municipality (2010): *Turistundersøgelse Stevns Kommune 2010 (Tourist Survey Stevns Municipality 2010)*, Stevns.

Transport til Stevns



Local infrastructure



8.2 Infrastructure

The infrastructure is to support the transport of local citizens, businesses and visitors. It is important that different interests be considered, that any conflicts between road users, local population and others are pre-empted and that any nuisances are minimised through efficient traffic planning.

The following account is limited to the immediate infrastructure that is the responsibility of Stevns Municipality or which the Municipality can influence directly.

8.2.1 Current situation

Today, the load on the infrastructure in Stevns Municipality is limited, and no significant problems have been found in relation to traffic management or conflicts between different interests. However, it is important that the infrastructure is continually improved in relation to development in the area. Stevns Municipality is very aware of this.

Road system

The road system in Stevns Municipality is fundamentally in good condition. The main road from the north to Store Heddinge and Rødvig is of a good standard and has sufficient capacity for handling traffic of local citizens, businesses and visitors in an efficient way. During rush hours, the main road between Køge and Stevns is overloaded, but this will only affect very few visitors.

In the buffer zones, the roads are smaller and of a local character, which is because the area is thinly populated. The primary roads along Stevns Klint are Korsnæbsvej between Rødvig and Højerup and Hærvejen between Højerup and Mandehoved. The first mentioned is part of *Margueritruuten* (The Marguerite Route), which is a Danish tourist route for motorists. Despite the fact that these are local roads, traffic currently flows well.

The only place along Stevns Klint where traffic management is inappropriate is at Espekærsvej by Mandehoved on the road to and from Stevns Nature Centre and Flagbanken. This road is too narrow for two busses to pass by each other.

Heavy commercial traffic around the chalk quarry Sigerslev Kridtbrud is the only extensive traffic in the area, but considering that an agreement between the owner, OMYA A/S, and Stevns Municipality about traffic handling via adequate roads works well, this traffic does not constitute a problem in relation to other traffic.

Stevns Municipality's Traffic Safety Plan 2010-2024 indicates that traffic safety issues have only been found to a limited degree in the area around Stevns Klint, and the registration of accidents shows that there is no pattern in the very limited number of accidents that have been registered in the area.²

Bus connections

Public transport to Stevns Klint is currently limited. There are bus connections to Rødvig and from there, a public flex taxi scheme, which can take visitors to Højerup and the other visitors' sites along Stevns Klint. Stevns Municipality continually considers how public bus transport can be improved in a viable operational economic way.

Østbanen

The train service that connects Rødvig, Store Heddinge and Køge is efficient and has frequent departures. From the stations, taxis and buses can take passengers further around Stevns.

Cycling routes

Stevns Municipality has a good and well-developed system of bicycle paths, which is continually being developed. There are good cycling routes along the entire Stevns Klint, but many of these need to be

² Stevns Municipality (2011): *Trafiksikkerhedsplan 2010-2014 (Traffic Safety Plan 2010-2014)*, Stevns Municipality.

connected to the overall system of bike paths and routes in Stevns Municipality.

The cycling route Berlin-Copenhagen passes through Rødvig, Højerup, Sigerslev, Mandehoved and Holtug, among others. As the narrow road Eskekærsvej forms part of this cycling route, cyclists move among car and bus traffic. Although there have not been any accidents involving cyclists along this stretch, it is assessed that there may be a conflict between the relatively soft and the heavy road users.

In 2011, a pocket-size cycling guide was published with six different routes around Stevns. All routes are linked to at least one train station and one public car park. The cycling routes are also interconnected.

Harbours

Both Rødvig Havn and Bøgeskov Havn are well-functioning harbours. At Rødvig Havn, there are good opportunities for using other modes of transport, such as bicycles, train, bus, taxi and walking. At Bøgeskov Harbour, the only way for yachtsmen to get about is to walk or use their own bicycles or mini-scooters.

Footpaths

The footpath called *Trampestien* is the backbone of ramblers' visits along Stevns Klint. *Trampestien* is well marked and equipped with experiences, facilities and services along the path. As such, *Trampestien* works well. The northern part of the footpath, which runs along a beach, is more difficult to walk along – particularly at times where high tide and south-east winds coincide. Work is in progress to make 100 metres of the path accessible to disabled and walking-impaired people.

Trampestien is not connected to other footpaths in Stevns Municipality.

Parking

Parking conditions along Stevns Klint are generally satisfactory. However, during the peak season, congestion issues may occur in Højerup, due to the parking conditions in the village. It is an increasing problem that cars are parked on private land or by the roadside outside the parking facilities. This is a nuisance both to local residents and to the traffic flow through Højerup.

Signage

Signage to Stevns Klint and the other sites of interest in the area is varied. In 2011, the Ministry of Transport has set up signs about Stevns Klint by the southern motorway E47 in north- and southbound directions, and Stevns Municipality is working on an agreement with Faxe and Køge Municipalities about signage to Stevns Klint.

Signage to sites of interest in Stevns Municipality is not adequate and should be improved.

Road directories

Online map material and GPS systems show visitors the shortest route. However, this is not always optimum in relation to traffic in Stevns Municipality.

8.2.2 Challenges

Currently, transport possibilities and the infrastructure are generally good and efficient. This should also be the case in the future. In order to achieve this, Stevns Municipality must collaborate with transport companies, Stevns Tourist Office and the local community to solve a number of challenges.

The challenges consist in:
Creating an efficient traffic flow, which includes directing visitors to the visitors' sites in an appropriate way.
Creating good connections between transport bottlenecks and visitors' sites.
Creating good public transport options to and between visitors' sites along Stevns Klint.
Developing cycling routes, including signage along Stevns Klint and the surrounding area.
Developing ramblers' routes along Stevns Klint and in the surrounding area.
Creating opportunities for visitors to combine several modes of transport during their visit to Stevns Klint.
Finding a lasting solution to parking problems in Højerup that considers both local citizens' interests and general traffic flow.
Encouraging suppliers of GPS systems to indicate routes to and in the area along Stevns Klint correctly and appropriately.
Ensuring funding for further development of infrastructure and construction work.

8.2.3 Objectives for infrastructure

It must be easy for visitors to get to Stevns Klint and visit the different sites of interest in the area with due regard for the local community.

Objectives for infrastructure
Prepare a traffic management plan that will ensure appropriate traffic flow in the area with least possible inconvenience to the local community's general quality of life.
Prevent traffic problems – especially with a focus on traffic safety, congestion and overload.
Create better traffic flow to Stevns Nature Centre.
Improve the infrastructure in Højerup, including the parking conditions.
Improve public transport to and between the visitors' sites along Stevns Klint, especially to Højerup.
Improve cycling and rambling routes to and between visitors' sites along Stevns Klint.
Create better possibilities of combining different modes of transport – especially with a focus on furthering cycling and rambling.
Establish lay-bys for auto campers.

8.2.4 Measures

In order to meet the challenges and achieve the listed objectives, Stevns Municipality plans to launch a number of measures that will improve infrastructure and traffic flow.

No.	Measure	Content	Time schedule	Responsibility
69	Plan Strategy 2011	Tourism is one of the main themes in Stevns Municipality's Plan Strategy in 2011. The Plan Strategy indicates the Municipality's areas of particular focus in the physical planning. Tourism as a theme will be added to the Municipal Plan 2013.	2011	Stevns Municipality
70	Traffic Plan for Stevns Municipality	A Traffic Plan for Stevns Municipality is to be drawn up with a view to ensuring appropriate traffic management and development of infrastructure in Stevns Municipality.	2014	Stevns Municipality
71	Bypass	The project related to the construction of a bypass around Strøby Egede has been launched. The bypass will improve traffic in the northern part of Stevns Municipality.	2016	Stevns Municipality
72	Tourist route	Establishment of a tourist route for motorists – among other things by redirecting the Marguerite route – with a view to improving accessibility, distributing visitors and increasing the visitor capacity.	2012 Awaiting funding	Stevns Municipality Stevns Tourist Office
73	Traffic management – Espekærsvvej	A solution is to be found for traffic management on Espekærsvvej by Mandehoved. This will include finding out whether bus traffic to Stevns Nature Centre and Flagbanken can be redirected, so that the traffic flow follows the same route as the heavy commercial traffic to Sigerslev Kalkbrud, thus being separated from the soft road users.	2012	Stevns Municipality
74	Rambling and cycling paths	Rambling and cycling paths along Stevns Klint are to be improved as part of a general increased priority given to rambling and cycling paths in the Municipality. It is to be ascertained whether it is possible to establish hikes that connect the cliff and Store Heddinge.	2011-16	Stevns Municipality
75	Signage – motorway	Signs are to be set up by motorway exits on the southbound motorway E47.	2011	Ministry of Traffic
76	Signage to Stevns	Work is in progress to improve signage to Stevns Klint from the motorway exits through Faxe and Køge Municipalities.	2011	Stevns Municipality

No.	Measure	Content	Time schedule	Responsibility
77	Signage in Stevns Municipality	An analysis is to be carried out of signage in Stevns Municipality and between the visitors' sites along the roads, with a view to improving information and optimising traffic flow.	2012	Stevns Municipality
78	Højerup – Local Plan	It has been decided to draw up a Local Plan for Højerup with the objective of adapting the village's infrastructure to receiving more visitors.	2012	Stevns Municipality
79	Højerup – pier and steps	A pier will be constructed by Højerup with a view to establishing a permanent sailing route between Rødvig and Højerup during the summer months. The steps that connect the cliff edge and the beach are to be improved.	2011-12 Awaiting full funding	Stevns Municipality
80	Trampestien footpath – Stevns Lighthouse	A 100-metre stretch of Trampestien is to be made accessible to walking-impaired people and wheelchair users.	2011	User group in collaboration with the Danish Nature Agency, Stevns Municipality, Stevns Nature Centre a.o.
81	Plan for auto campers	A mapping is to be carried out of possible locations for auto campers within the buffer zones and in Rødvig and Store Heddinge.	2012	Stevns Municipality Stevns Tourist Office
82	Car park for auto campers at Rødvig Havn	The possibility of establishing a site for auto campers by Rødvig Havn is to be investigated.	2012	Stevns Municipality Stevns Tourist Office
83	Boesdal Kalkbrud – footbridge for disabled people	A footbridge will be established to enable wheelchair users and walking-impaired people to reach the beach and see the geological stratification.	2012 Awaiting funding	The association Foreningen Boesdal Stevns Municipality
84	Flagbanken and Mandehoved	An addendum to the Municipal Plan and a Local Plan for the barracks area by Mandehoved are expected to be approved politically. The intention is that the area is to be developed with respect for the building cultural and landscape qualities that are found in the area.	2011	Stevns Municipality

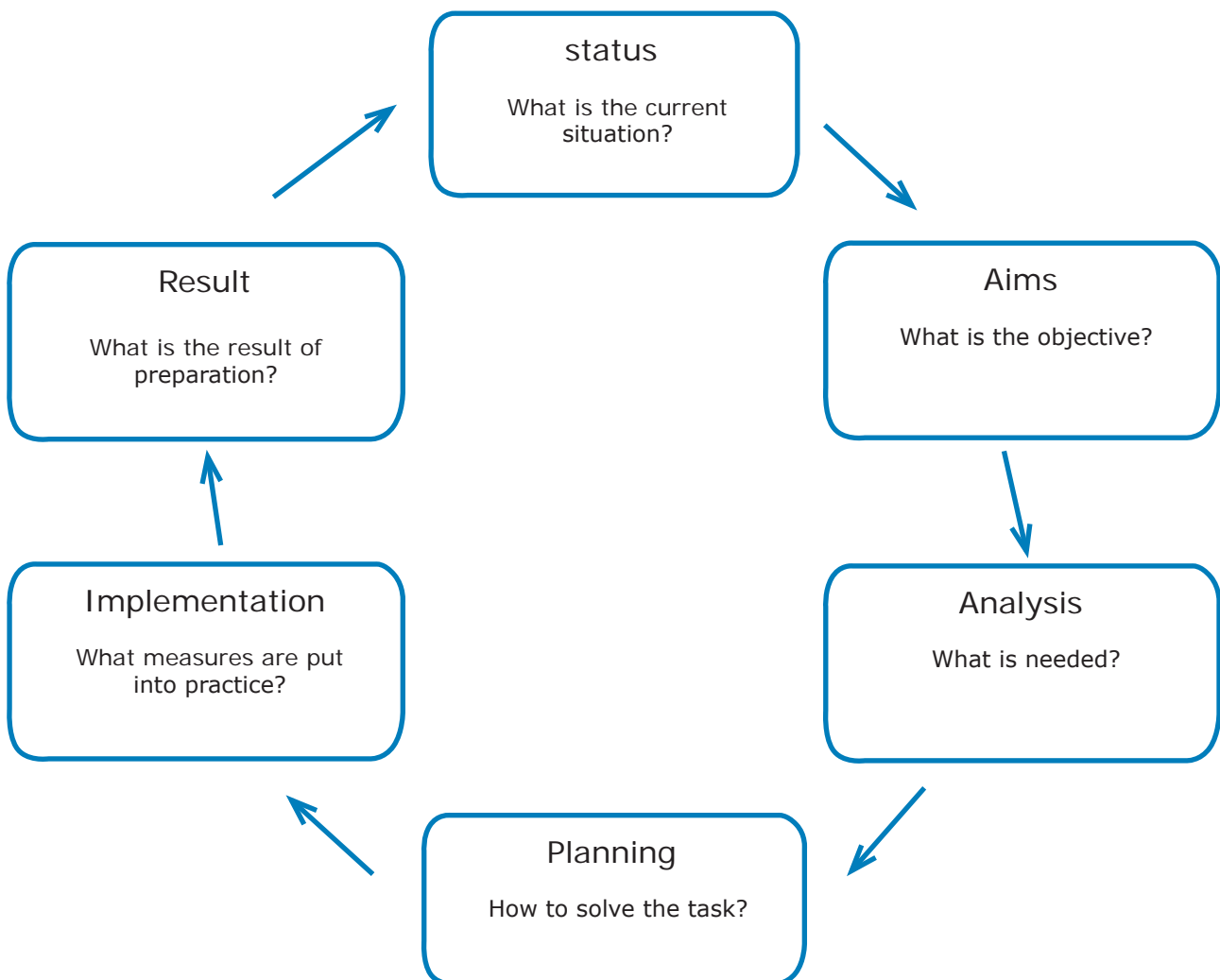
No.	Measure	Content	Time schedule	Responsibility
85	The Trampestien footpath	Marking and information along Trampes-tien are being improved.	2011-12	Stevns Municipal-ity in collaboration with Østsjællandss Museum
86	The Berlin-Copenhagen cycling route	It is to be ascertained whether it is possible to extend the Berlin-Copenhagen cycling route to run via Hovedskovsvej to Bøgeskov and further on through the forest Gjorslev Skov to Strøby Ladeplads with a view to raising the experience-related quality of the cycling route and increasing road safety.	2013	Stevns Municipality Stevns Tourist Of- fice
87	Shuttle	It is to be ascertained whether it is possible to run a shuttle bus between the visitors' sites and Rødvig and Store Heddinge.	2014	Stevns Municipality Stevns Tourist Of- fice Østsjællandss Mu- seum
88	GPS route plans	It is to be ascertained whether GPS com-panies can change the route plans so that information and directions are not in conflict with the local Traffic Plan and Traffic Safety Plan.	2012	Stevns Municipality

9 Monitoring and Evaluation

Pursuant to the regulations for World Heritage laid down by UNESCO, the condition of the nominated area's core values must be monitored.¹ The objective of monitoring a number of main factors is to obtain indications about the nominated area's status, including any changes in the conservation condition.² Monitoring procures valuable information, which is to be evaluated and used in connection with the future management of the area, so that the vision, objectives and targets for Stevns Klint can be reached. Based on evaluation, it will be possible to assess whether the management of Stevns Klint is efficient and appropriate. In other words, monitoring and evaluation are management tools that will help safeguard Stevns Klint's values and integrity.

Efficient monitoring presupposes collecting of updated information about the indicators that show the condition of Stevns Klint, its values and the human impact on this. It is important that this information be precise and reliable, and that monitoring can continually be carried out based on the same methods. Furthermore, it has been stressed that monitoring must be realistic, practical and satisfactory in relation to the means available for the purpose.

Monitoring and evaluation follow the cycle shown below.



1 UNESCO (2008): *Operational Guidelines for the Implementation of the World Heritage Convention*, World Heritage Centre, p. 33.

2 UNESCO (2010): *Preparing World Heritage Nominations*, first edition, Paris, p. 92.

9.1 Stevns Klint's Outstanding Universal Value

Monitoring the geological stratification and the integrity of the nominated area – i.e. the outstanding universal value and the intactness of the cliff – is the most significant monitoring task along Stevns Klint. Monitoring must consider factors that can be used as indicators for Stevns Klint's integrity, protection and management.

The Monitoring Plan shown below will be launched in 2011 and 2012. This monitoring will show whether further monitoring measures are needed. As mentioned in Chapter 4.1.4, Østsjælland's Museum will continue to work on developing efficient monitoring of Stevns Klint's condition.

No.	Focus	Indicator	Method	Evaluation	Frequency	Responsibility
89	Retrogradation	Retrogradation of Stevns Klint	Retrogradation and slides registered from land and from the sea.	Assessment of the retrogradation's impact on core values and integrity	Continually	Østsjælland's Museum Stevns Municipality Plot owners
90	Collecting of geological material – in general	State of geological layers, particularly fish clay and traces of tools in the geological layers	The state of the geological layers and traces of tools are registered and mapped – particularly around the visitors' sites Boesdal Kalkbrud, Højerup and Holtug Kridtbrud.	Comparison of information from year to year will provide answers as to whether the geological value and the integrity are endangered now or in the longer term.	During the months of May and October Every year	Østsjælland's Museum
91	Collecting of geological material – research	Research activity in the nominated area	Researchers are encouraged to notify Østsjælland's Museum of their field studies, so that the Museum can register these and assign research areas. The aim is to make this compulsory in the long term.	Assessment of where and to what extent Stevns Klint can sustain research activity at the given time	Continually Cf. item 90	Østsjælland's Museum
92	Vantage points	Clear view to Stevns Klint from vantage points	The vantage points along Stevns Klint are checked for overgrowth and anything else that might limit or block a clear view.	Assessment of whether overgrowth or anything else obstructs the visual experience of Stevns Klint	Annually	Stevns Municipality Østsjælland's Museum

9.2 Nature

The nature areas along Stevns Klint are monitored with a view to obtaining information that can contribute to the management of nature in future.

No.	Focus	Indicator	Method	Evaluation	Time schedule	Responsibility
93	Flora and fauna	A number of specific animals and plants that thrive on the oligotrophic limestone pastures.	Monitoring and registration of specific plants and animals at select pastures along Stevns Klint.	Quantitative measuring to ascertain whether biodiversity in the nature areas improves. Assessment of whether the preservation plans live up to their objectives.	Annually	Stevns Municipality
94	Wear and waste in nature	Wear of vegetation and waste as a result of human activities in the nature areas and on the footpath along Stevns Klint.	Wear and waste in and around the nature areas is registered by means of observations, photos and mapping.	Assessment of whether wear constitutes a problem. Assessment of waste handling in nature. During the peak season, the cliff should be monitored for removal of waste at least once a week.	Annually	Stevns Municipality Østsjælland Museum The Danish Nature Agency The society Selskabet Højeruplund The association Foreningen Boesdal

9.3 Research and dissemination

The objective of monitoring the communication is to ensure that information about Stevns Klint is sufficient to satisfy the different target groups. Monitoring of research in the area may contribute to updating the presentation content.

No.	Focus	Indicator	Method	Evaluation	Time schedule	Responsibility
95	Research	Published articles	Retrieval of published articles from peer-reviewed journals.	Overview of new research and assessment of how this could possibly be communicated to visitors.	Annually	Østsjællandss Museum.
96	Communication	Satisfaction with information boards, guided tours, visitors' centre etc.	Survey among visitors. This will be carried out as part of a survey of visitors' experiences, see Chapter 9.4.	Quantitative and qualitative assessment of whether the communication meets visitors' present and future needs .	Annually	Stevns Municipality Stevns Tourist Office Østsjællandss Museum

9.4 Tourism

Monitoring of tourism is to secure information that shows whether the capacity to receive visitors is adequate; whether Stevns Klint complies with visitors' needs and requirements; how and to what degree wear and tear impact the visitors' sites, and whether due consideration is given to the general well-being of the local people.

No.	Focus	Indicator	Method	Evaluation	Time schedule	Responsibility
97	Plot owners' experiences	Tourism's effect on plot owners' general behaviour in the nominated area. Special focus on the footpath Trampes-tien.	Plot owner meetings are held.	Assessment of plot owners' experience in relation to the overall value of the nominated area.	As a min. once a year.	Stevns Municipality
98	Wear and waste at the visitors' sites	Wear and tear of visitors' site facilities, including the footpath. Path formation at the visitors' sites. Waste left behind.	Wear, path formation and waste in and around the visitors' sites are registered by means of observations, photos and mapping.	Assessment of whether wear constitutes a problem. Assessment of waste handling at the visitors' sites.	Annually	Østsjællandss Museum Stevns Municipality Plot owners

99	Visitors' experiences	Visitors' assessment of Stevns Klint, the visitors' sites, facilities, services, information etc.	Survey among visitors.	Quantitative and qualitative assessment of visitors' experiences and requirements.	Every two years	Stevns Municipality Stevns Tourist Office Østsjællandss Museum
100	Statistics	Overnight stays Number of visitors Distribution	Information is gathered from places offering overnight accommodation and visitors' sites.	Assessment of the capacity for overnight stays, visits and distribution.	Annually	Stevns Tourist Office

9.5 Infrastructure

Monitoring of the infrastructure is to ensure that traffic is managed in an appropriate way.

No.	Focus	Indicator	Method	Evaluation	Time schedule	Responsibility
101	Traffic load	Queue formation Traffic accidents	Traffic census Mapping of reported accidents.	Assessment as to whether traffic management is efficient for all types of road users.	Every two years	Stevns Municipality
102	Parking	Parking problems	Parking problems are registered through observations and photos.	Assessment of efficiency of parking conditions at visitors' sites.	Annually	Stevns Municipality Plot owners Østsjællandss Museum

10 Funding

Funding of the measures listed in this Management Plan is completely fundamental to development along Stevns Klint. Emphasis has been placed on ensuring development on a financially sustainable basis. The vast majority of the indicated measures are currently funded either through the everyday operation or through projects run by Stevns Municipality, Østsjælland Museum or other of the involved players.

It is a challenge to secure funding for the measures that do not have financial backing yet. However, this is a challenge that will be met through fundraising and municipal means. The status that comes with being a candidate for inscription on UNESCO's World Heritage List – and provided Stevns Klint is accepted onto the World Heritage List – can be used in connection with fundraising.

10.1 Necessary items

Funding of measures related to protecting, conserving, monitoring and presenting the geological values are the crucial items. This is a prerequisite for designation as a UNESCO World Heritage Site and for remaining on the World Heritage List. It is thus a necessity that funding is found for the items listed below.

Necessary items
An organisation with knowledge about the core values, presentation and monitoring. The organisation is to ensure a professional and management-related anchoring.
Protection of the geological values.
Conservation of the geological values.
Monitoring of the geological values.
Facilitation of research.
Presentation of the geological values, including a visitors' centre that will serve as a focal point for presentations, guided tours, exhibitions, teaching and research.

Through support from the foundations Nordea Fonden and Augustinus Fonden, Østsjælland Museum has procured funding for a number of presentation-related measures.

10.2 Other items

In order to achieve a desirable output in relation to nature-related, socio-cultural and financial potentials, respectively – especially in relation to the development of sustainable tourism – funding of the measures that are not covered by the items mentioned in Chapter 10.1 are important items. These items will help safeguard the development of Stevns.

Many of the items are currently funded through operation or projects.

Appendix 1 – Citizen Involvement

It is the fundamental desire of the Heritage Agency of Denmark, Stevns Municipality and Østsjælland's Museum that local plot owners, citizens and other stakeholders be involved in the process of having Stevns Klint inscribed on UNESCO's World Heritage List. This has resulted in, among other things, a number of planned plot owner and citizens' meetings, articles and adverts in local media, use of stevns.dk and other communication activities. The project's communication plan has been used actively to control communication in the process of having Stevns Klint inscribed on UNESCO's World Heritage List.

It is the intention to continue involving plot owners, citizens and others in aspects that concern them one way or the other.

1.1 Participatory democracy and citizen involvement policy

Stevns Municipality's Participatory Democracy and Citizen Involvement Policy¹ has formed the basis for involvement of plot owners, citizens and other stakeholders. The objective of the policy is to ensure an open, close and constructive dialogue between Stevns Municipality and the citizens, associations, businesses, interest organisations, councils and others in the municipality.

The Participatory Democracy and Citizen Involvement Policy builds on four strategic statements:

1. The citizens of Stevns must be given the opportunity to be heard and involved in connection with political decisions. The citizens of Stevns must be given real opportunities to participate as early and as often as possible in issues that are of importance to their everyday lives in Stevns Municipality.
2. Citizens' knowledge and awareness of local conditions must contribute to raising the quality of the politicians' decisions. Politicians and the administration must utilise the specific knowledge and the particular interests that citizens have from their daily activities in the municipality.
3. Citizen involvement is to lead to greater understanding of and sense of ownership for political decisions. Processes for participatory democracy and citizen involvement are to give the citizens increased co-responsibility and co-ownership in relation to municipal activities. As far as possible, citizens are to contribute to anchoring and maintaining the general strategies, plans and projects on which they have had an influence.
4. Citizen involvement and interest in co-ownership must be encouraged. Citizens should experience that they are co-responsible for the community and the development of the municipality and the local areas.

During the process of preparing the Management Plan, emphasis has been placed on finding solutions that build on professional assessments and which are locally anchored. Plot owners, citizens, experts, local advisory organs, interest organisations and other stakeholders have been involved in the process.

¹ Stevns Municipality (2010): *Politik for nærdemokrati og borgerinddragelse (Participatory Democracy and Citizen Involvement Policy)*, Stevns.

1.2 Plot owner and citizens' meetings

Plot owners and citizens have been involved through a number of plot owner and citizens' meetings. These meetings have been led by an external, neutral facilitator. The facilitator's task was to ensure that agendas were followed and that discussions maintained their focus and to recapitulate and communicate on comments, proposals, experience, wishes etc.

During the process, three plot owner meetings have been held. The plot owners' meetings were held behind closed doors in order to create an atmosphere of peace and comfort, so that the dialogue between plot owners, Stevns Municipality and Østsjælland's Museum could take place freely and without hindrances. The purpose of the plot owners' meetings was to allow the plot owners to express values, challenges and development possibilities along Stevns Klint. The plot owners were also given the opportunity to air their concerns about the project. This has contributed to raising the quality of the measures that are described in the Management Plan.

Four citizens' meetings were also held. The first citizens' meeting was purely an information meeting about Stevns Klint's inscription on UNESCO's Tentative List. An account was given of why Stevns Klint is outstanding and of what it will take to be acknowledged as World Heritage.

The second citizens' meeting was a closed meeting to which only citizens of Højerup were invited – some 165 households. The purpose of this meeting was also to allow the citizens to express their attitudes to Stevns Klint's values, challenges and development potentials. The citizens' meeting resulted in a lot of positive feedback, which has been applied in the preparation of the Management Plan.

The third citizens' meeting had the form of a vision and development workshop, during which citizens worked together to express the potentials that will result from a possible inscription on UNESCO's World Heritage List. The outcome was many good and concrete proposals, a number of which have been included in the Management Plan. Other proposals from citizens have been saved for future use.

The fourth and final citizens' and stakeholders' meeting dealt with the Management Plan. After a presentation of the Management Plan's contents, citizens and other stakeholders were invited to express their views and comment on the contents.

In parallel to the citizens' meetings about Stevns Klint's inscription on UNESCO's World Heritage List, four citizens' meetings have focused on the most important values in Stevns Municipality under the heading of *Stevns i Vækstgear* (Stevns Gearing up to Growth) – an independent development project funded by Stevns Municipality and the EU's Rural Development scheme 2007-2013. An overwhelming number of citizens indicated that Stevns Klint is what binds the community together.

The stakeholders listed below have been introduced to the Management Plan and have had the opportunity to comment on its contents.

List of stakeholders who have been heard (in alphabetical order)
Bøgeskov Fishing Harbour
Citizens in Stevns Municipality
Citizens of Højerup
Cold War Museum Stevnsfort
Danish Nature Agency

Danish Nature Agency, Stevns
Danish Ornithology Association
Danish Outdoor Council
Danish Society of Nature Conservation
Danish Society of Nature Conservation, Stevns
Foreningen Boesdal (association)
Heritage Agency of Denmark
Højerup Citizens' Association
LAG Stevns
OMYA A/S
Østsjælland's Museum
Plot owners and neighbours along Stevns Klint
Rødvig Harbour
Selskabet Højeruplund (society)
Stevns Business Council
Stevns Green Council
Stevns Municipality
Stevns Nature Centre
Stevns Tourist Association
Stevns Tourist Office
Stevns Village Council
The Cultural Council

1.3 Other involvement of stakeholders

In the autumn 2010, Stevns Municipality purchased Squadron 543 by Stevns Lighthouse. In this connection, the Municipality has involved citizens in relation to development opportunities for the area. This involvement process continues.

A user group is in continual dialogue with Stevns Municipality about management of Stevns Lighthouse and development of the area around the lighthouses. This involvement process continues.

There has been a continual dialogue with associations and interest organisations that are affiliated with or have interests in Stevns Klint. The purpose of the dialogue has been to ensure a professional approach to some concrete issues and to strengthen the local anchoring.

1.4 Communication

In the process of preparing the inscription application and the Management Plan, Stevns Municipality and Østsjælland's Museum have worked strategically with communication. This work has taken its starting point in a communication plan, so that communication has been controlled, targeted and adapted to specific target groups in relation to the project's milestones, decisions and consequences.

The communication effort has taken its starting point in the individual target group. This means that the same information has not necessarily been communicated in the same way to the different target groups, and what has been communicated and how this has been done has been differentiated.

The basis for the communication effort is the good story. The main message to the different target groups is that along with Stevns Klint's possible inscription on UNESCO's World Heritage List comes an obligation to protect, conserve and present the core values. In addition, the message is that the project is a unique opportunity for Stevns as a whole and for Denmark, which we can be proud of and support. If Stevns Klint is designated a World Heritage Site, this could become a lever for the development of all of Stevns.

The target groups for project Stevns Klint as World Heritage consist of 1) primary target groups, who have very extensive interests in the project and who may have decisive influence on the process, and 2) secondary target groups who have great or medium interests in the project and to some degree may affect, but do not have decisive influence on the actual application process.

The primary stakeholders are always given first priority. The objective is that this group should not experience that significant results/conclusions are made public before they have been informed or involved. Communication to secondary target groups often happens by 'allowing them to sneak a peek' at the communication to the primary target groups.

The choice of communication channels depends on the individual communication situation. The communication channels used are those that are assessed to be most efficient in relation to the individual communication situation. Close contact is also maintained with the local newspapers, Dagbladet and Stevnsbladet, both via meetings and via press releases. In the period from 2009 to mid 2011, they have published a combined total of about 60 articles on the process of having Stevns Klint inscribed on the World Heritage List.

One important aspect of the communication is to ensure a sensible flow. The chart below shows the communication flow in the course of the work on the application and the Management Plan for 'Stevns Klint as World Heritage'. In future, the communication plan will continually be updated with various activities up until and after a possible nomination.

Time	Activity	Target group	Sender	Media	Status
Continually	Dialogue about the project's development and progress	Heritage Agency of Denmark The Danish Nature Agency	Stevns Municipality	Meeting, email etc.	Conducted continually
29/9 2010	Geology info meeting	Researchers	Østsjællands Museum via the Geological Society of Denmark	Local newspapers	Has been held
28/10 2010	Museum Director Tove Damholt participates in Board meeting in Højeruplund	The Højeruplund Board	Østsjællands Museum	Meeting	Has been held
2/11 2010	Meeting with Green Council	Interest organisations	Østsjællands Museum Stevns Municipality	Meeting	Has been held
4/11 2010	Annual meeting for plot owners along the foot-path Trampestien Brief information about future meetings	Plot owners	Stevns Municipality	Meeting	Has been held
9/11 2010	Email address for the project – verdensarv@stevns.dk	Anyone who wants to ask questions about the project	Stevns Municipality	Email	In operation
11/11 2010	Plot owner meeting / Workshop	Plot owners North – Stevns Nature Centre	Museum Director Tove Damholt Stevns Municipality	Personal letter Media	Has been held
12/11 2010	Exhibition Flagbanken	The general public	Østsjællands Museum	Exhibition	In operation
23/11 2010	Plot owner meeting / Workshop	Plot owners South – Stevnsfort	Østsjællands Museum Stevns Municipality	Personal letter	Has been held
29/11 2010	Plot owner meeting / Workshop	Plot owners Centre – Højeruplund	Østsjællands Museum Stevns Municipality	Personal letter	Has been held

Time	Activity	Target group	Sender	Media	Status
30/11 2010	Citizens' meeting / workshop	Citizens meeting for Højerup – Højeruplund	Østsjællandss Museum Stevns Municipality	Follow-up media info after the three plot owners' meetings and one of the citizens' meetings Minutes sent to plot owners after the meeting	Has been held
Early December 2010	World Heritage at stevns.dk – Development of web pages Banner on home page	The general public Users of stevns.dk	Stevns Municipality	Stevns.dk	Completed
December / January	Logo Guidelines for use of the logo prepared	General public Public face of the Steering Group / the project	Østsjællandss Museum Stevns Municipality		In progress
spring 2011	Meeting with Højeruplund	The Højeruplund Board	Østsjællandss Museum	Meeting	Has been held
spring 2011	Meeting with Højeruplund	The Højeruplund Board	Stevns Municipality Østsjællandss Museum	Meeting	
6/1 2011	Meeting with the press	Dagbladet Stevnsbladet	Stevns Municipality Østsjællandss Museum	Meeting	Has been held
17/1 2011	Citizens' meeting	Open meeting for all citizens in Stevns – Højeruplund	Stevns Municipality	Two adverts in Stevnsbladet, 100 posters put up in the Municipality, 60 invitations to contact people in the villages	Has been held
18/1 2011	Press release about citizens' meeting	All citizens in Stevns	Stevns Municipality	Local media	Has been sent
1/2 2011	Media – new logo After Steering Group meeting	The general public	Steering Group Stevns Municipality	The media Guidelines for use of the logo prepared at the same time	Have been sent

Time	Activity	Target group	Sender	Media	Status
February 2011	Media – signs Easywins after plot owners' meetings	The general public	Stevns Municipality Østsjællandss Museum	Local media	Pending
February 2011	Lecture The Cultural Council	Meeting participants	Østsjællandss Museum	Meeting	Has been held
8/3 2011	Lecture Nordea's Annual Meeting	Nordea's clients, Stevns (350 participants)	Østsjællandss Museum	Meeting	Meeting
1/5 2011	Exhibition at Stevns Museum and book about fossils	The general public	Østsjællandss Museum	Exhibition	Has been held
17/5 2011	Meeting with the press	Dagbladet Stevnsbladet	Stevns Municipality Østsjællandss Museum	Meeting	Has been held
May 2011	Info meeting / Workshop	Stevns Business Council	Stevns Municipality	Local newspapers / email / newsletter	
24/5 2011	Citizens' meeting	All plot owners and citizens	Stevns Municipality	Personal letter Media	Has been held
2011	Press release about info meeting with Stevns Business Council	The general public	Stevns Municipality	Local newspapers	Has been held
2011	The pamphlet <i>Oplev Stevns Klint (Experience Stevns Klint)</i>	The general public and tourists	Østsjællandss Museum	Pamphlet	Every year
2012	Publishing of the book 'Stevns Klint'	The general public and tourists	Østsjællandss Museum	Book	next year



The scenic coastal cliff Stevns Klint comprises the most spectacular global mass extinction event in the history of the Earth: The Cretaceous—Tertiary boundary. The mass extinction that occurred 65 million years ago is particularly spectacular due to its association with an asteroid impact and because it marks the extinction of more than half of all species, including land-living dinosaurs and large marine reptiles.

At Stevns Klint the thin, black boundary clay found in the up to 40 m high, white cliff clearly marks the abrupt fall in primary production and makes the exceptional boundary visible even to the inexperienced eye. Stevns Klint is an outstanding locality representing a major stage in Earth's history and the record of life: The mass extinction at the Cretaceous—Tertiary boundary and is nominated for inclusion for the World Heritage List.

STEVNSKLINT
STEVNSKLINT
STEVNSKLINT



Nomination of

STEVNS KLINT

for inclusion in the World Heritage List

Appendix 5: Erosion Analysis



Nomination of
STEVNS KLINT

for inclusion in the World Heritage List

Appendix 5: Erosion Analysis



Rockfalls at Stevns Klint

Landslide hazard assessment based on photogrammetrical
supported geological analysis of the limestone cliff
Stevns Klint in eastern Denmark

Stig A. Schack Pedersen



GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF CLIMATE AND ENERGY



Introduction

Occurrence of rockfalls along the coastal cliff Stevns Klint has been common knowledge since the famous landslide in 1928, which separated the choir of the old Højerup church from its nave. Landslides are regularly occurring along Danish coastal cliffs (Pedersen et al. 1989), but at Stevns Klint the outcropping geology provides a special geomorphologic framework prone to cliff collapse. All along the c.10 km long coastal cliff section Stevns Klint (Fig. 1) the Danian bryozoan limestone constitutes the upper part of the cliff, which is resting on the soft Maastrichtian chalk at the base (Surlyk, Damholt & Bjerager 2006). The Danian limestone is a hard lithology in which the internal framework of hardgrounds and flint bands mainly occurring in mound shaped features increases its resistance to erosion (Figs 2, 3). In the lower part of the cliff the soft chalk is easily eroded and excavated, while the Danian limestone forms an overhang, which occasionally breaks off or collapses. The presence of the marl and clay at the boundary between the chalk and the limestone, the Fiskeler Member (Surlyk, Damholt & Bjerager 2006), contributes to the planar base of the overhang. The impressive view of the most dramatic overhangs will commonly encourage visitors to think twice before they take decide to pass below the overhang with its potential for collapse.

The aim of this report

It has been decided to make an assessment of the risk of rockfalls along the Stevns Klint chalk and limestone cliff. The rockfall risk analysis has been initiated by Østsjælland Museum, who is responsible for compiling the application for Stevns Klint to be admitted to UNESCO's list of World Heritage Sites. Consequently, GEUS has been asked to make an analysis the rockfall risk of the Stevns Klint. The assessment is summarized in this report, which is based on a geological and geomorphologic analysis of overhang, cliff vulnerability and rockfall dimensions along the coastal cliff at Stevns Klint. The analysis is based on a photogrammetric investigation of a series of oblique photographs, which were taken of the cliff section in the end of April 2011. Subsequently, the cliff section was mapped in segments and detailed photogrammetric measurements were carried out by the application of the computer working station SOCESET in the photogrammetric laboratory at GEUS. The photogrammetric survey was saved in an ArcGis format, which in the future will be available for other projects and applicable for future comparison of the cliff-collapse development. Similarly the terrestrial photogrammetric investigation of the cliff with oblique photographs taken in 1992 (Surlyk et al. 2006) was applied for comparative analysis of the rockfall development during the past 20 years.

The analysis is divided into detailed investigations of 22 segments (Pedersen & Strunck 2011) (Fig. 1). A similar division into well known segments from south to north was also applied by Surlyk et al. (2006). Furthermore the general conditions of cliff erosion are described, and an introduction to the rockfall mechanisms is provided with a description of the characteristics of the various types of landslides.

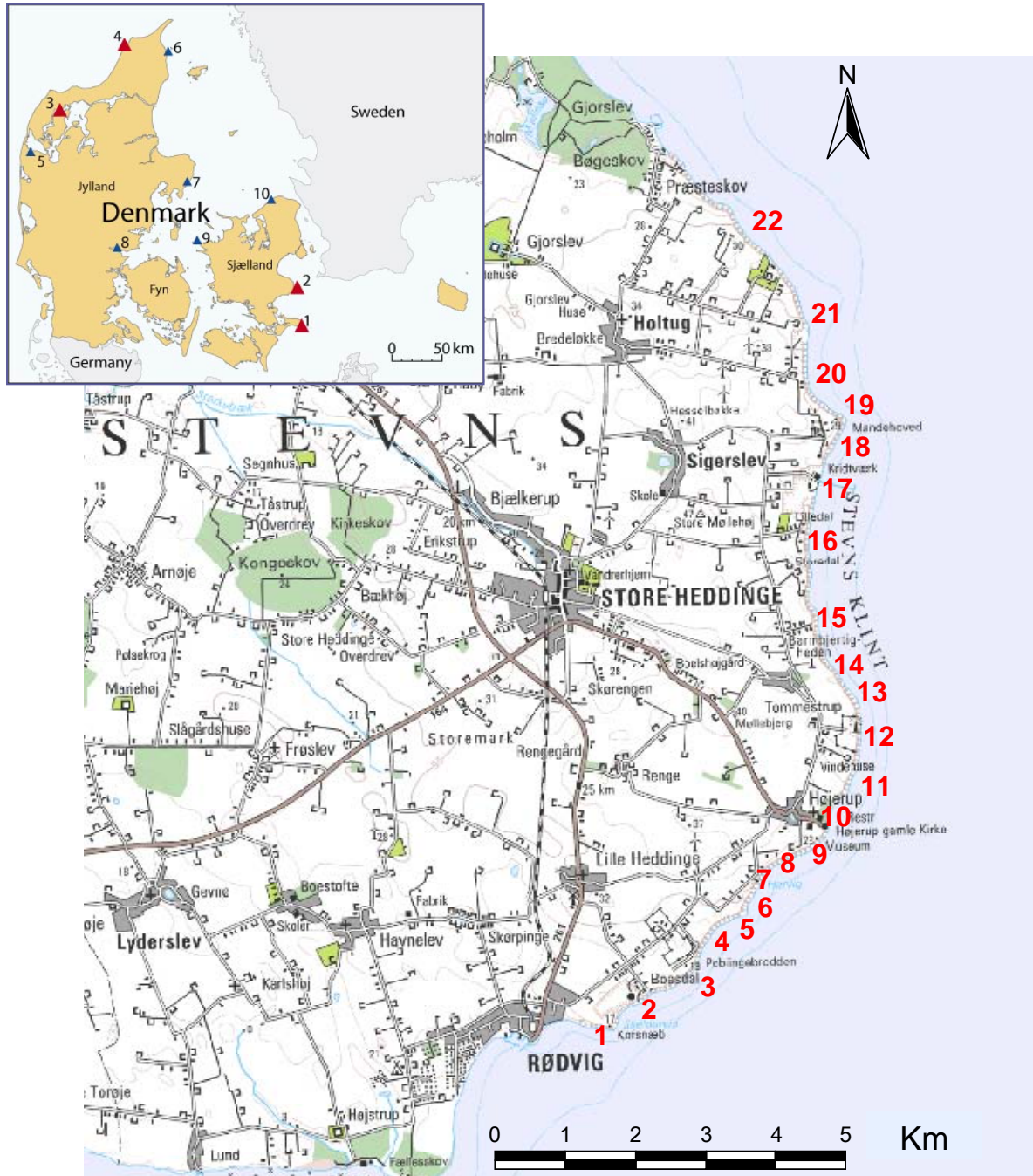


Figure 1. Location map of Stevns Klint with the division into segments indicated by red numbers. The insert map in the upper left corner shows the distribution of landslides in Denmark, where the red triangles are most hazardous slides and blue ones refer to clayey landslides. Stevns Klint is red triangle no. 2, and Møns Klint mentioned in the text is no. 1. Also mentioned in the text is no. 4: Lønstrup Klint, where the highest rate of coastal erosion in Denmark, up to 1.25 m/y occurs.

General erosional conditions at Stevns Klint

One of the essential factors for rockfall assessment is the rate of erosion. The general rate of coastal erosion at Stevns Klint is estimated to 15 cm/year from comparison of the position of the coast line in 1891 with the coast line given by the National Survey and Cadastre in 2010. The highest rate is about 35 cm/year, which occurs at the coast segment between Storedal and Lilledal (Loc. 16 in Fig. 1). However, in some places the coast line also shows signs of progradation, partly due to accumulation of beach ridges and partly because old landslides remains preserved along the coast, where they act as wave breakers. The first case is especially pronounced at Korsnæb (Loc.1 in Fig. 1), where the accumulation rate amounts to 12 cm/year. The latter case is well illustrated by the landslides at Højerup old church, where the translated landslide body is still preserved as a 12 m progradation of the coast line (Loc. 10 in Fig. 1) partly stimulated by coastal protection. Furthermore, the landslides north of Kirkevig (Loc. 11 in Fig. 1) has also resulted in an progradation of the coast line about 7–9 cm/year, and a similar advance of the coast line is present south of Storedal (Loc. 15 in Fig. 1). In general the erosion rate of Stevns Klint must be regarded as modest, when it is compared to the highest rate of erosion along the Danish coast line, which is 1.25 m/year at Lønstrup Klint (Pedersen 1986) (for location see Fig. 1).

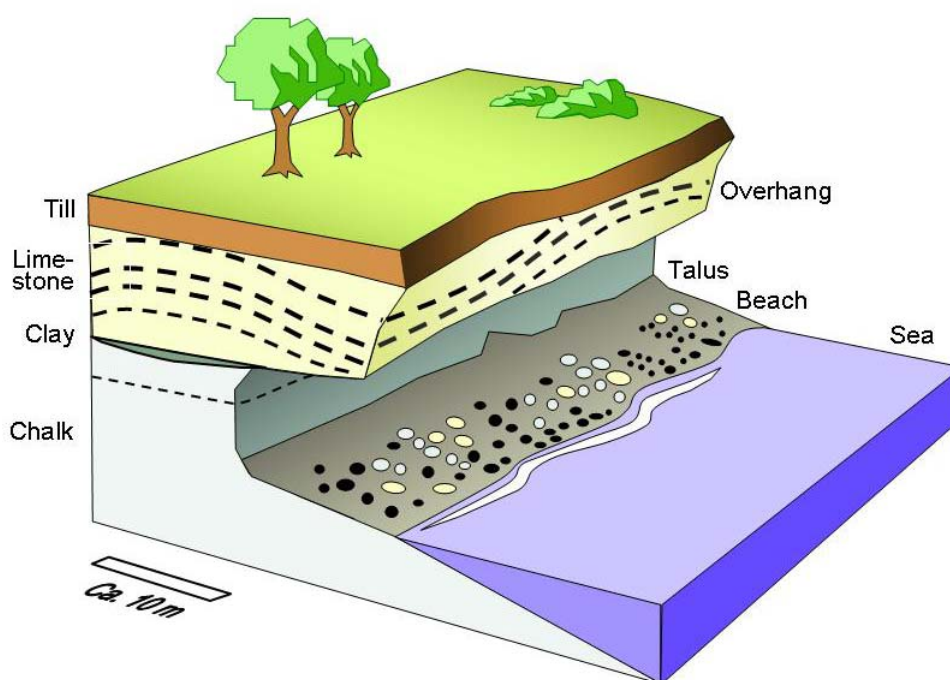


Figure 2. The block diagram illustrates the main geology and geomorphology of the coastal cliff at Stevns Klint. At the base of the geological succession the white chalk is soft and subjected to erosion. The hard Danian limestone forms the overhang above the Cretaceous/Tertiary boundary (C/T) at the base of the clay. Details about the lithostratigraphy are given in Fig. 3.

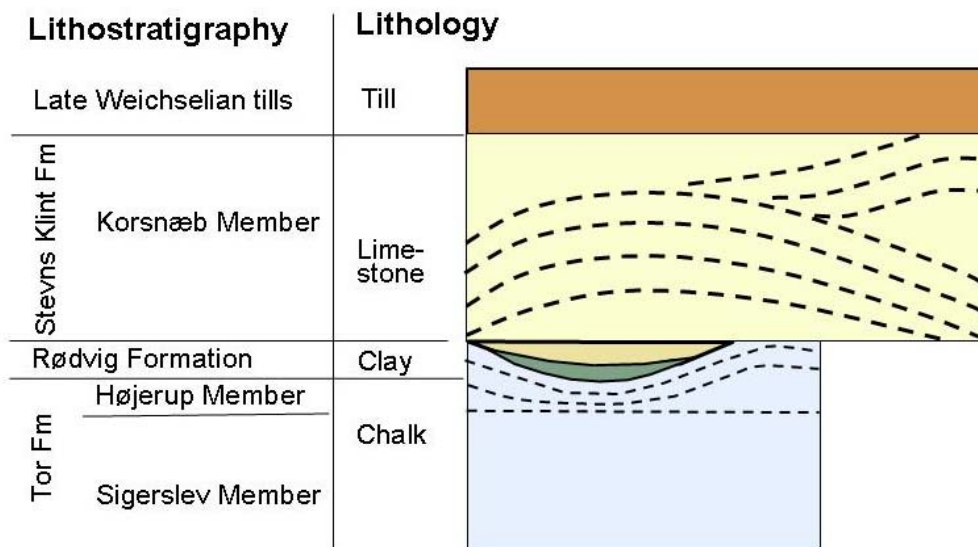


Figure 3. Lithostratigraphical division of the geological units present in the Stevns Klint coastal cliff section. The lower part of the succession constitutes the Maastrichtian chalk (uppermost part of the Cretaceous), which at Stevns Klint is divided into two members of the Tor Formation, the Sigerslev Member and the Højerup Member (Surlyk et al. 2006). The boundary between the two members is situated 0.5 m above the prominent black, nodular flint bed in top of the Sigerslev Member. The Højerup Member comprises smaller bryozoan mounds in the depression of which the Rødvig Formation is located (Surlyk et al. 2006). In the diagram the lithology is indicated as clay referring to the Fiskerler Member (fiske-ler.: fish clay, the famous C/T boundary unit) . The clay grades up into a marl, which in the depressions is overlain by the Cerithium Limestone Member. The Rødvig Formation and the top of the mounds in the Højerup Member are truncated by a hardground at the base of the Stevns Klint Formation (Surlyk et al. 2006). The Stevns Klint Formation corresponds to the Danian bryozoan limestone, which at Stevns Klint is only represented by the up to 20 m thick Korsnæb Member. The unit is characterised by the flint beds outlining the bryozoan mounds that create the curved features of the hard, resistant limestone in the top of the cliff sections. The Korsnæb Member is truncated by an erosional unconformity upon which the Weichselian glacial deposits occur. Part of the truncation was formed during the glacial advance resulting in shearing and cataclastic displacement of the limestone resulting in the formation of a limestone-glacitectorite at the base of the till. The till unit is generally 3 m thick, but varies a lot and two beds may be recognised, which are related to the Mid Danish Till Formation and the East Jylland Till Formation (Houmark-Nielsen 2007) representing ice advances from central Sweden and the Baltic, respectively, during the Late Glacial Maximum at the termination of the Pleistocene.

It is not only the natural coastal erosion that affected the cliff disintegration. The traces of human activity over the past hundreds of years are recognized as square excavation marks in many places along the cliff. The small limestone quarries were excavated in rectangular pits with walls inclined towards the base resulting in considerable overhang. In 16 m high walls these overhang can be up to 6 m at the top jutting out over the floor of the pits. The excavation profiles may contribute to the cliff points projecting out above the beach.

Characterization of rockfalls at Stevns Klint

The rockfalls at Stevns Klint do not belong to the biggest and most hazardous class of landslides (Pedersen, Foged & Frederiksen 1989). An obvious reason for this is simply the height of the cliff, which is about 40 m at the highest point at Stevns Fyr (the lighthouse) in the central part of the coastal cliff (Loc. 12 in Fig. 1). From this point the height of the cliff decreases towards the north and south where the cliff height is only 15–20 m. Thus rock avalanches does not occur at Stevns Klint in contrast to those occurring at Møns Klint (Fig. 1), where the latest landslide took place in January 2007, and resulted in the collapse of the 100 m high cliff St. Taler and an avalanche carried debris more than 300 m out into the sea (Nadim et al. 2008, Pedersen & Gravesen 2009). Moreover the rockfalls at Stevns Klint are solely related to the erosion of the soft chalk situated below the hard bryozoan limestone with its increased strength due to the strong flint beds (Fig. 2, 3).

The largest type of landslides at Stevns Klint may be characterized as a **cliff-slide** (Fig. 4). This type of slide includes a major part of the cliff several tens of meters along strike of the coast line, which slipped simultaneously. In general the cliff-slide takes place along a steeply dipping slip surface and the volumes involved are in the order of 5–10.000 m³.

In relation to size the next type of large slides is the **cliff-fall** (Fig. 4). This type of rockfall involves only isolated projecting points of the cliff with a considerable overhang. The cliff-fall is a simple drop of the cliff in which the bedding of the fallen block is preserved after the displacement. It looks just like a box of rock has been dropped onto the beach. The volume involved in the cliff-fall is in the order of 500 m³ to 1500 m³.

The third type of slides is classified as a **rockfall** (Fig. 4), and varies in size from 500 m³ to 1 m³. In areas where a lot of till is involved a mixed type of landslide occurs, which may be characterized as a block-slide, in which bigger blocks were displaced together with more fine-grained material. Meanwhile, the resulting aggradation of material on the beach after a rockfall is a chaotic breccia with a cataclastic mixture of the entire range of grain-sizes.

On the scale of 1 m³ a significant type of rockfall appears at Stevns Klint, which is here referred to as **rock-bedding exfoliation** (Fig. 4). This type of platy rockfall appears in caves eroded out by the storm waves. From the roofs of the caves layers are peeled off due to exfoliation and dish shaped pieces of rock drops to the floor.

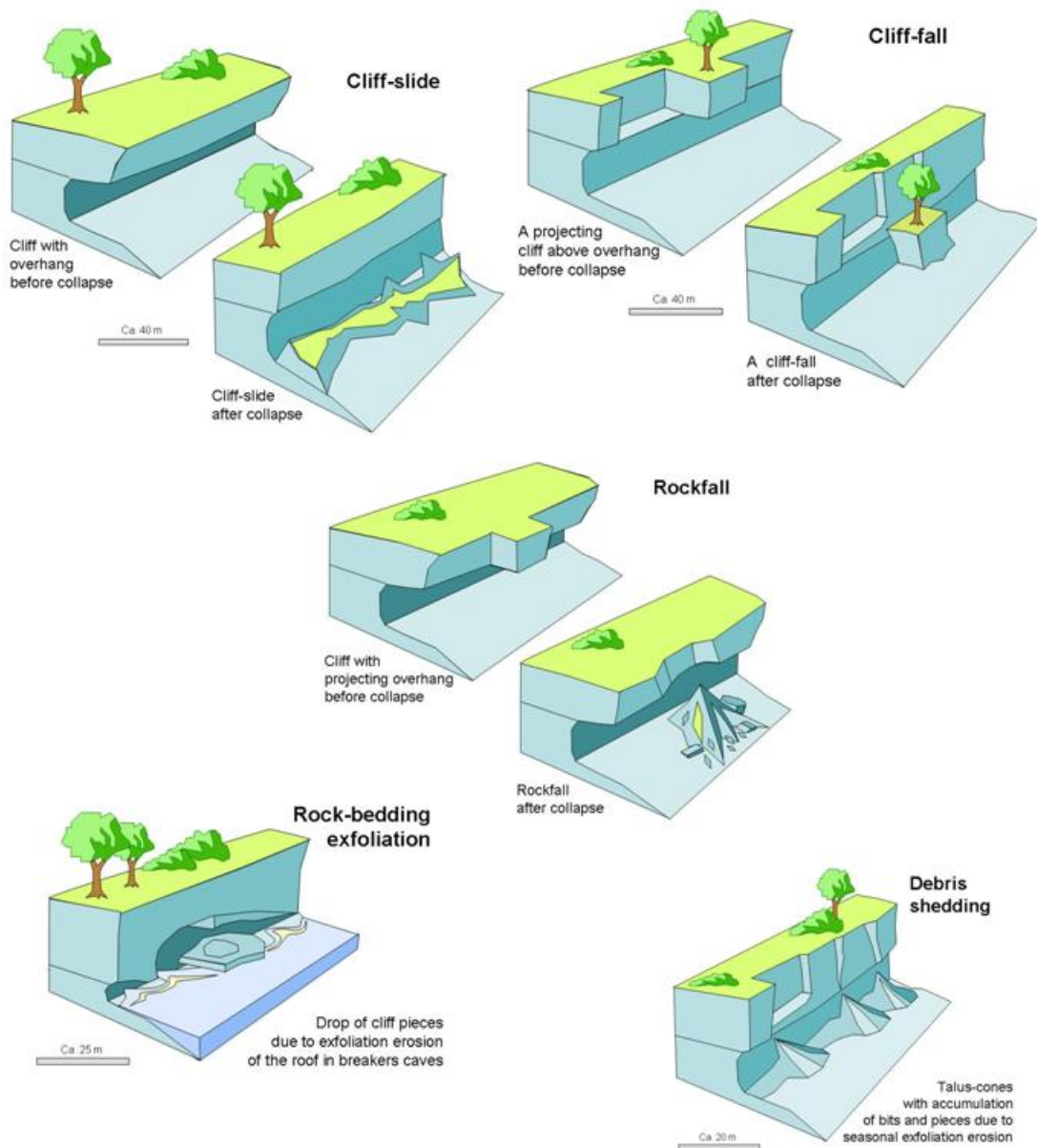


Figure 4. Characterisation of the rockfall types occurring at the chalk and limestone cliff along Stevns Klint. The most hazardous type is the cliff-slide involving volumes in the order of 5000 m^3 . The cliff-fall only includes volume in 500 m^3 size, but it gives an impressive prospect with the bedding completely preserved in a displaced cliff. The rockfall is the general type of landslide with a pieces of the cliff translated into a debris cone. The rock-bedding exfoliation generates platy limestone blocks the size of $1\text{--}10 \text{ m}^3$, which drop off from the roof below the overhangs. The main erosion along the cliff is due for debris shedding, which is responsible for the talus at the toe of the cliff.

Finally pieces of rock may fall from the cliff due to the general **debris shedding** (Fig. 4). In general the grain sizes of debris shedding are pebbles and cobbles and only occasionally clasts of stone-size are loosened from the cliff surface. The result of the debris shedding is seen as an apron of talus along the toe of the cliff, typically with irregular cone shape. The cause of the debris shedding is the seasonal contraction and expansion due to seasonal variation of frost and thaw in the winter time and desiccation during the summer.

The best known rockfalls in Denmark are the collapse of Stevns Klint below the Højerup old church (Rasmussen 1967) and the rockfall at Møns Klint that killed a French tourist in the summer 1994 (Pedersen 1994). The landslide at Højerup old church may be characterized as a cliff-slide in the classification illustrated in Fig. 4. The slide was a typical early spring event (March 1928) were the frost and thaw and general expansion and contraction due to temperature variations triggered the slide. The disastrous rockfall at Møns Klint was just a peak of rock that toppled due to its loss of cohesion due to desiccation by the July sun.

The cliff-slides at Stevns Klint

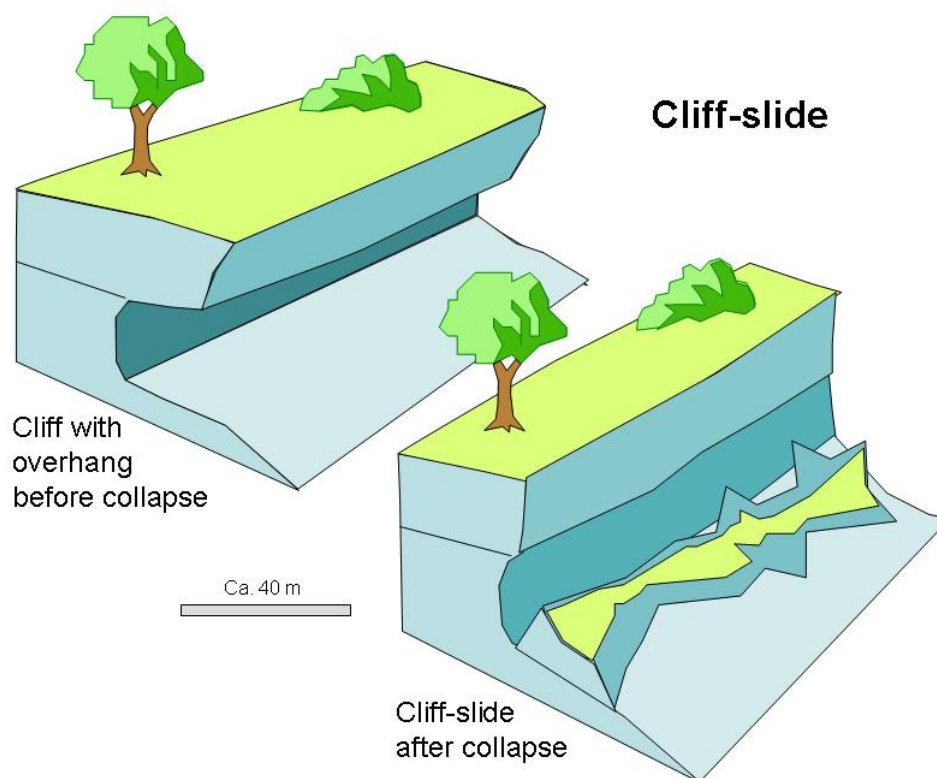


Figure 5. *The cliff-slide is characterised by the drop and slide of an overhang, which extend for about 100 m along the coastal cliff. The cliff-slide takes places where a long section of the chalk cliff is exposed to erosion from the sea for a long period (50-100 years).*

The rockfall type at Stevns Klint which involves the largest volumes is classified as cliff-slide (Fig. 5). Prior to a cliff-slide a whole section of the chalk was eroded away to create an undercutting below the limestone resulting in a considerable overhang. The size of the overhang is about 10–12 m and the thickness of the limestone and till in the overhang is about 15–18 m. The landslide at Højerup old church is regarded as representing such a slide (Figs 6, 7). The map in Fig. 7 shows the extent of this landslide, which prograded several tens of meters out into the sea. Today a coast protection with erratic blocks secures the survival of the remaining part of church for more than hundred years (Fig. 6).

Two other significant examples of cliff-slide are found north of Stevns Fyr at the locality indicated as Tommestrup (no. 13 in Fig. 1) (Fig. 8) and in the inner part of Harvig (no. 7 in Fig. 1) (Fig. 9). At both sites these landslides will serve as coastal protection for about half a century.

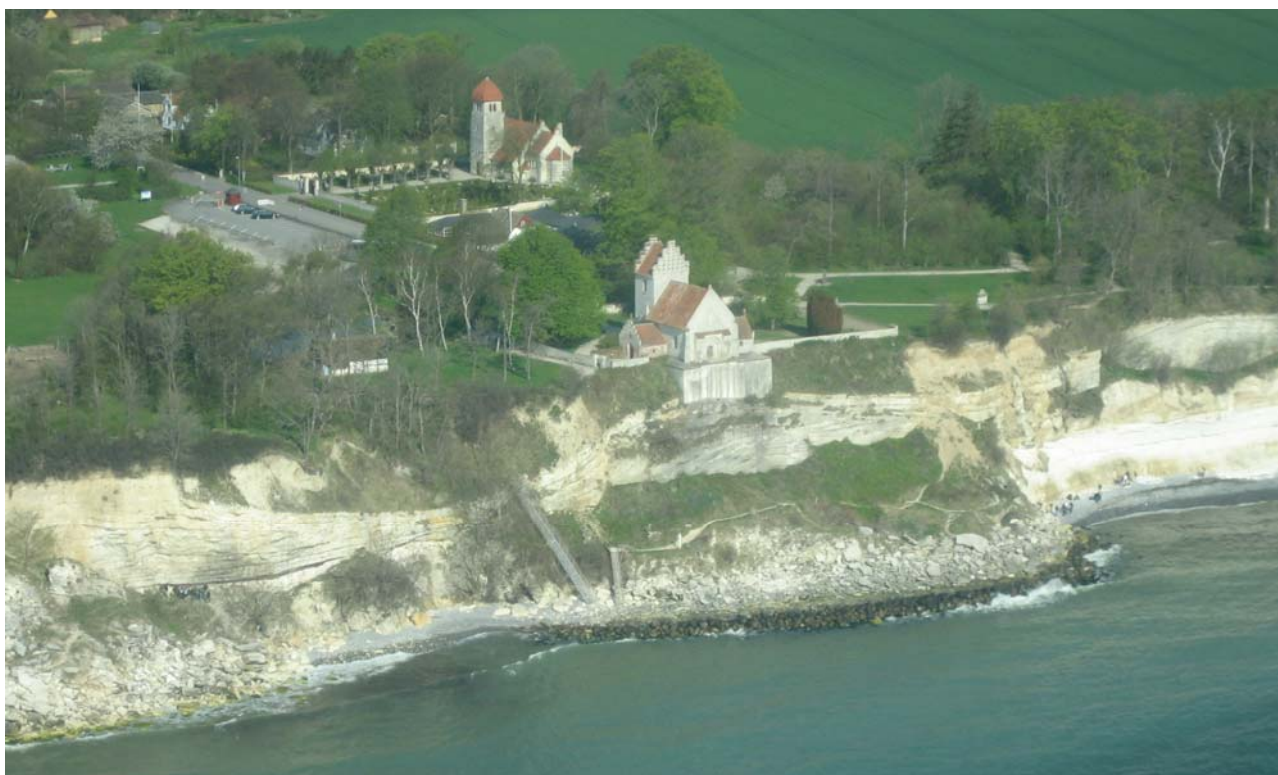


Figure 6. *The landslide at Højerup old church. The top of the landslide body is c.15 m a.s.l. and the toe of the slide is protected against erosion with blocks and boulders. The new church in Højerup was built in 1913 due to the local fear for destruction of the old church by a landslide.*

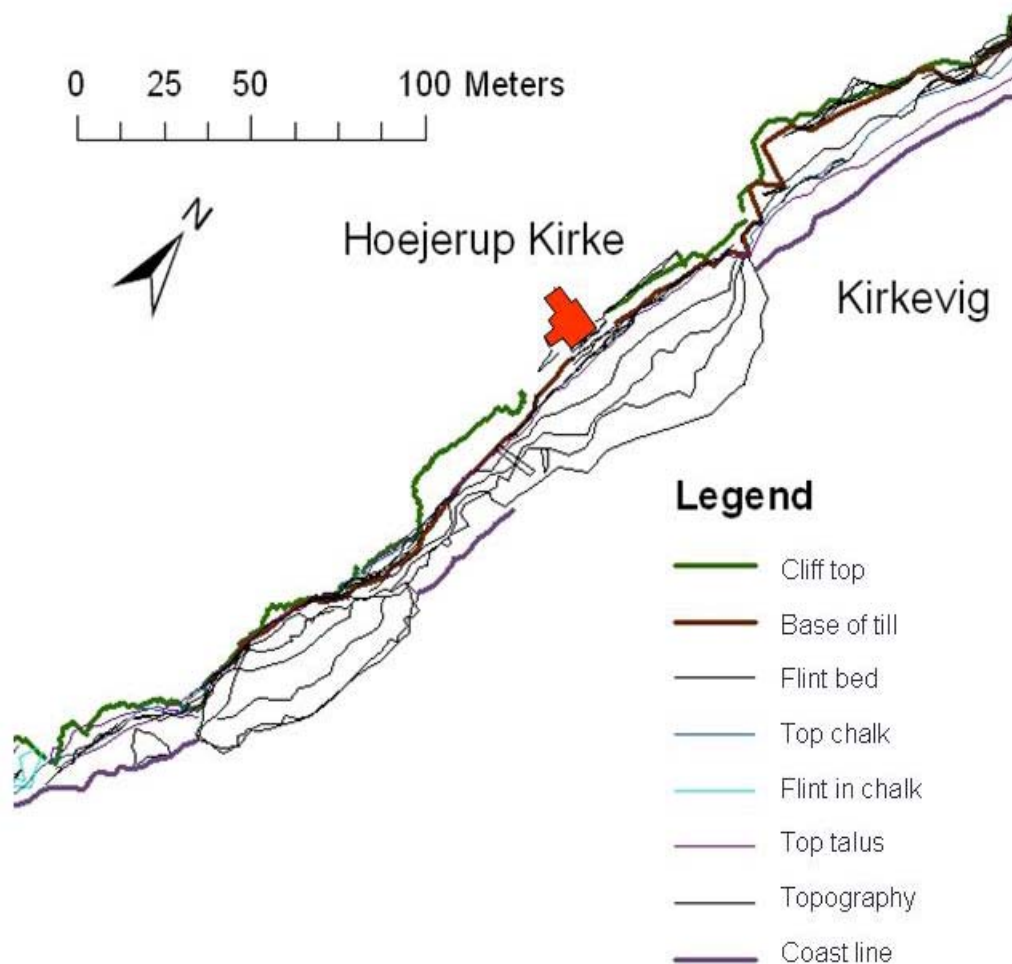


Figure 7. Photogrammetric traced contours which document the conditions at the coastal cliff along Stevns Klint. The cliff top is defined as the point of inflection from the more or less horizontal ground above the cliff and the steeply incline surface of the cliff. The base of the till outlines the boundary between the till and the Danian limestone. Flint bed represents the tracing of representative flint layers on the cliff surface. In a vertical display of data these tracings outline very clearly the geometry of the bryozoan mounds as also demonstrated by Surlyk et al. (2006). In the horizontal display here and in the following maps of the photogrammetric tracings the lines represent an “average” position of the surface of the limestone cliff overhang. Top chalk is a mixture of line tracings, but it mainly represents the Rødvig Formation, which is indicative of the deepest erosion below the overhang. Flint in chalk may even represent a further undercutting of the chalk. It is mainly traced along the flint beds and hardgrounds at the boundary between Sigerslev and Højerup Members. Top of talus is the interface of the toe of the cliff and the talus cones. Topography outlines all other elements of interest. In the landslides 2.5 m contour intervals have been traced. On top of the cliff small quarries have been traced, and a few buildings and steps are also outlined with this line type. Finally the wave-breaking zone has been traced to give an indication of the width of the foreshore.



Figure 8. *An example of a cliff-slide with preserved vegetation on top of the landslide. In the left side of the air-photo a recent rockfall is recognisable. Locality Tommestrup no. 13 in Fig. 1.*



Figure 9. *The cliff-slide in the inner part of Harvig (Loc. 7 in Fig. 1). The measured length of the slide along the coast is 90 m and the thickness of the displaced stratigraphy is 12 m which corresponds well with the thickness of the limestone and till in the cliff. The width of the surface in the slide is 7-10 m which consequently corresponds to the depth of undercutting below the overhang.*

The cliff-falls at Stevns Klint

The cliff-fall is a term here used for indicating a specific part of the cliff that has dropped to the toe of the cliff (Fig. 10). In the displaced cliff the bedding is still preserved and it has not been subjected to noticeably rotation. The size of the blocks have been measured to be about 1200–1500 m³, and the surface area measures 100 m² indicating an overhang of about 10 m for a limestone cliff thickness of about 12–15 m.

One of the best examples of a cliff-fall is seen below the Stevns Fyr lighthouse (Loc. 12 in fig. 1). Here a rectangular part of the cliff has dropped directly to the beach (Fig. 11, 12). The thickness of the bryozoan limestone in the cliff section is about 22 m, whereas the thickness of the displaced block is only 12–14 m. This discrepancy is explained by former excavation in an old limestone quarry, which has removed c. 10 m of the limestone. The relation between limestone thickness and overhang is thus in the order of 3 to 2, which corresponds to the average measurements of rockfalls along the cliff.

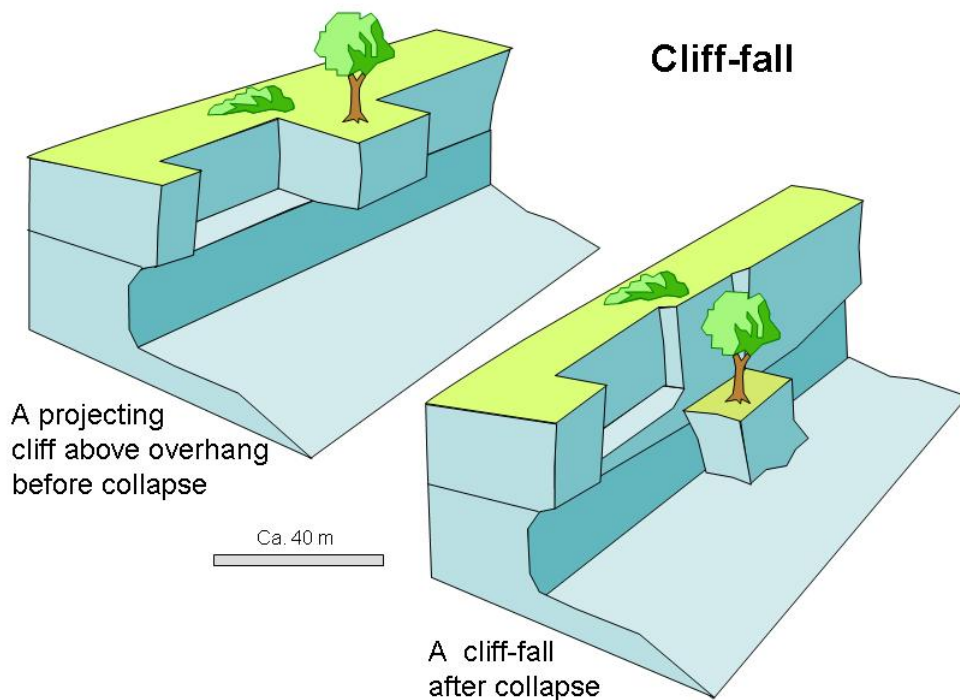


Figure 10. Principal sketch of a cliff-fall. Note that this type of rockfall typically affects a protruding point of the cliff due to former limestone quarrying along the coastal cliff.

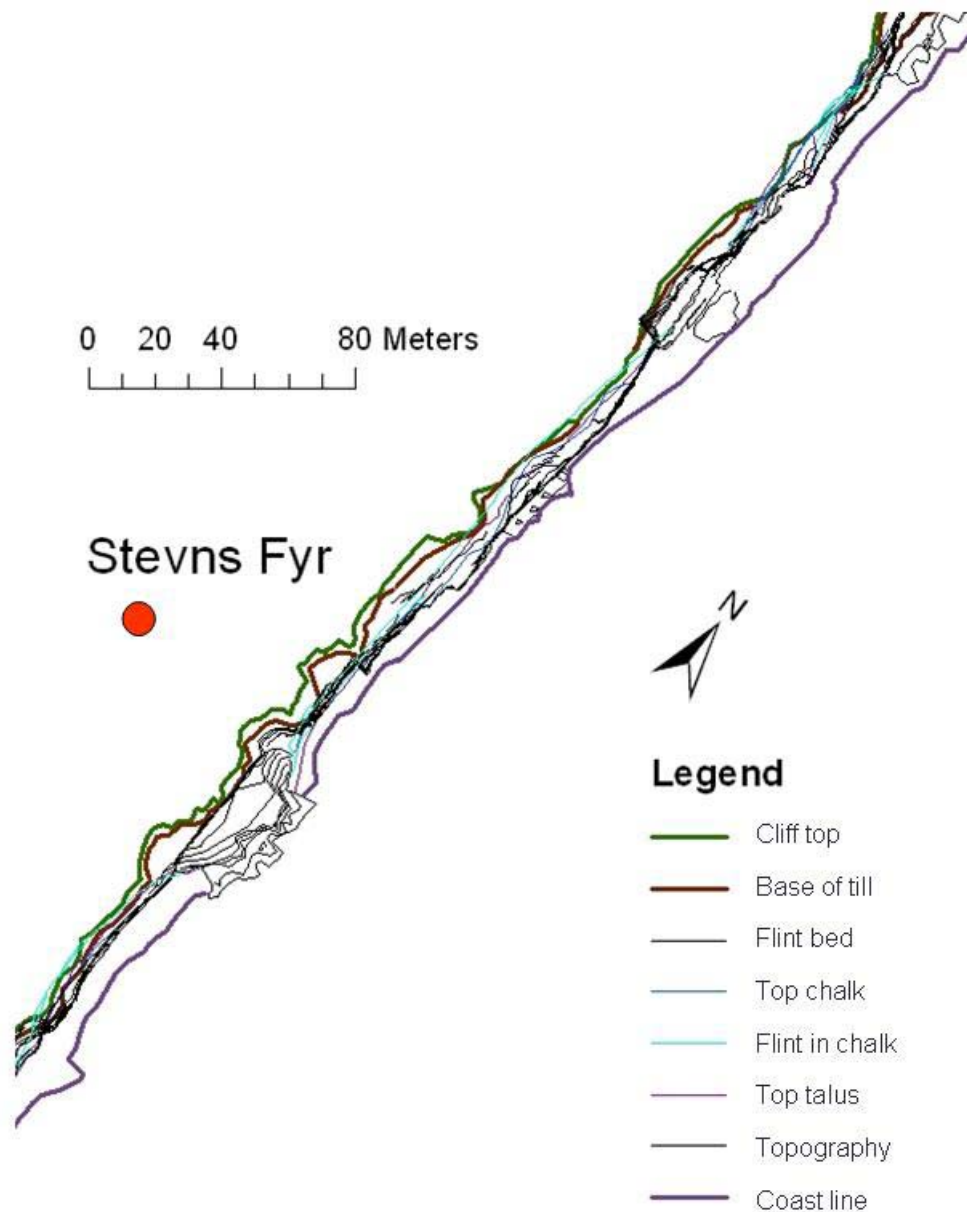


Figure 11. Photogrammetric contour map of the area at Stevns Fyr (lighthouse). The cliff-fall is located immediately southeast of the lighthouse. The topographic contours outlining the cliff-fall have intervals of 2.5 m. The steep and squared walls of the cliff-fall can easily be seen as well as the flat top at a height of 12.5 m. Note the rectangular outline of the old limestone quarries on top of the cliff. Note also the size of the overhang north of the cliff-fall, which is given by the distance between the thin blue lines (top chalk and flint in chalk) and the black lines (traces of flint bands in limestone). The overhang amounts to 8–9 m, which is close to the maximum value of overhangs along the cliff. Explanations to the contour lines are given in Fig. 7.



Figure 12. Photo of the cliff-fall and the large overhang at Stevns Fyr. The lighthouse is located at the highest point along Stevns Klint, 41.5 m a.s.l. Below and north of the lighthouse the rectangular shaped small limestone quarries can be seen. Note that under the substantial overhang a small pile of blocks indicate a rock-bedding exfoliation of the roof below the overhang. This type of erosion contributes to the decrease in the thickness of the overhang, which decreases its strength and thus increases its tendency of a cliff-fall (or cliff-slide).



Figure 13. An additional example of cliff-fall from the inner part of Lille Hedding Vig (Loc. 4 in fig. 1). The cliff-fall is seen just below the yellow house, and its dimension of 1200 m³ corresponds well with the general magnitude of cliff-falls.

The ordinary type of rockfalls at Stevns Klint

A number of ordinary rockfalls are present along Stevns Klint (Fig. 14). Their sizes vary between 100 m^3 and 1 m^3 , but may occasionally be up to 1000 m^3 . The largest blocks involved in the rockfalls are up to 50 m^3 . Frequently the rockfalls includes thicker beds of till displaced from the top of the cliff into mixed cataclastic breccias. The exact mechanism of these slides is not fully understood, but it seems as if sequential steps of sliding may facilitate block-sliding.

In the present analysis three modern rockfalls are recognized. These represent collapses of the limestone cliff within the last 20 years, determined from the comparison of the present and the earlier photogrammetric photo series. The dimension of the rockfall amounted to 1000 m^3 , and none of them was in the category of cliff-slides. One of these has already been mentioned and is shown in Fig. 8. In the southern part of the cliff section a reactivation of an older rockfall is recognized at Korsnæb (Loc. 1 in Fig. 1). This slide is estimated to amount 1000 m^3 . However, it probably represents a mixed landslide, which includes a considerable amount of till as well as glacially broken chalk from the top part of the limestone in Korsbnæb Member. With a cliff height of 16 m the slide cannot be regarded as dramatic, although the overhang is situated 6.5 m a.s.l.

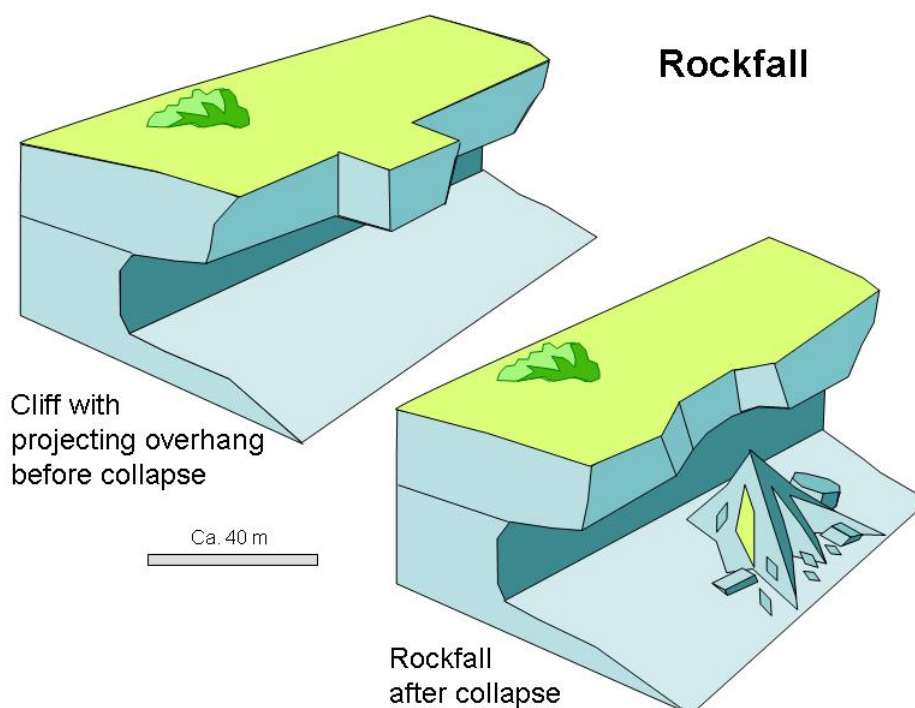


Figure 14. The block diagrams illustrate the ordinary type of rockfalls occurring at Stevns Klint. The rockfall accumulates a cone shaped pile of debris at the foreshore, and a concave escarpment is created in the cliff.

In general the rockfalls leaves a concave escarpment in the cliff and the aggradation of debris results in a cone expanding out into the sea. In Fig. 15 an example of one of the larger rockfall is shown. This rockfall is situated c. 200 m south of Stevns Fyr. The top of the cliff is here 38 m a.s.l., and the uppermost 4 m comprises a till bed. The base of the overhang is situated in 13,5 m a.s.l., and the extension of the debris reached 60 m from the cliff surface.

The relation between the height of the cliff and the translation of rockfall material is estimated to be one to two. In a cliff-fall this ratio is one to one (or less), wherefore it is speculated that a stepwise dynamic of the rockfall is involved, which adds clayey material to the debris pile on which the concluding rockfall is sliding. A support to this speculation is the nature of the present overhang located north of the slide. Here the horizontal base of the overhang is 4 m deep. However, the tip of cliff top is projecting 8 m out over the foreshore. The reason for this inclined limestone cliff surface is the former excavation which gradually oversteepened the excavation wall. Therefore a rockfall initiated by dropping the outermost part of the cliff will bring the till down to the ground, and the subsequent rockfall of the main part of the limestone will slip on the initially dropped clayey material.



Figure 15. *The large rockfall c. 200 km south of Stevns Fyr. Note the 3–4 m thick till unit at the top of the cliff. The clay content in the till contributed to a mixed rockfall development.*

The rock-bedding exfoliation at Stevns Klint

The rock-bedding exfoliation is a significant erosion mechanism at Stevns Klint. It is typically related to cave eroded by breaking waves, which wash directly against the toe of the cliff (Fig. 16). This type of erosion is enhanced by the structure of the bryozoan limestone, because the roof of the caves coincides with the bedding of the bryozoan mounds as seen in the overhang shown at Stevns Fyr (Fig. 12). From the roofs of the caves layers are loosened due to exfoliation and slaps with thicknesses of c. 0.3 m and diameters of up to 3 m have fallen from the roofs to the floor.

Caves are especially developed along stretches of the coast where shore-parallel transport is strong enough to remove the well-rounded pebbles and cobbles of flint, which form the typical foreshore along Stevns Klint (Fig. 20, 21). Caves are prominent at Boesdal (Loc. 2, in Fig. 1), north of Stevnsfortet (transition from Loc. 3 to 4), south of Storedal and at Holtug (Loc. 16 and 21). At Boesdal (Fig. 17) the C/T boundary, and thus the base of the bryozoan limestone is located close to sea level. Here the caves are undercutting the limestone and stretch up to 9 m into the cliff (Figs 16, 17).

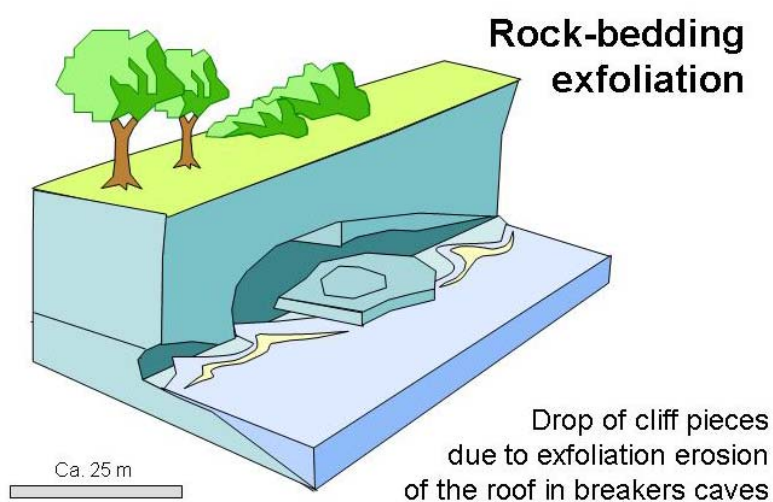


Figure 16. The block diagram illustrates the erosion of breakers, which creates arc-formed caves at the base of the cliff. The layers in the antiformal shaped mounds are peeled off and platy bedding-blocks are successively dropped to the shore.

Boesdal

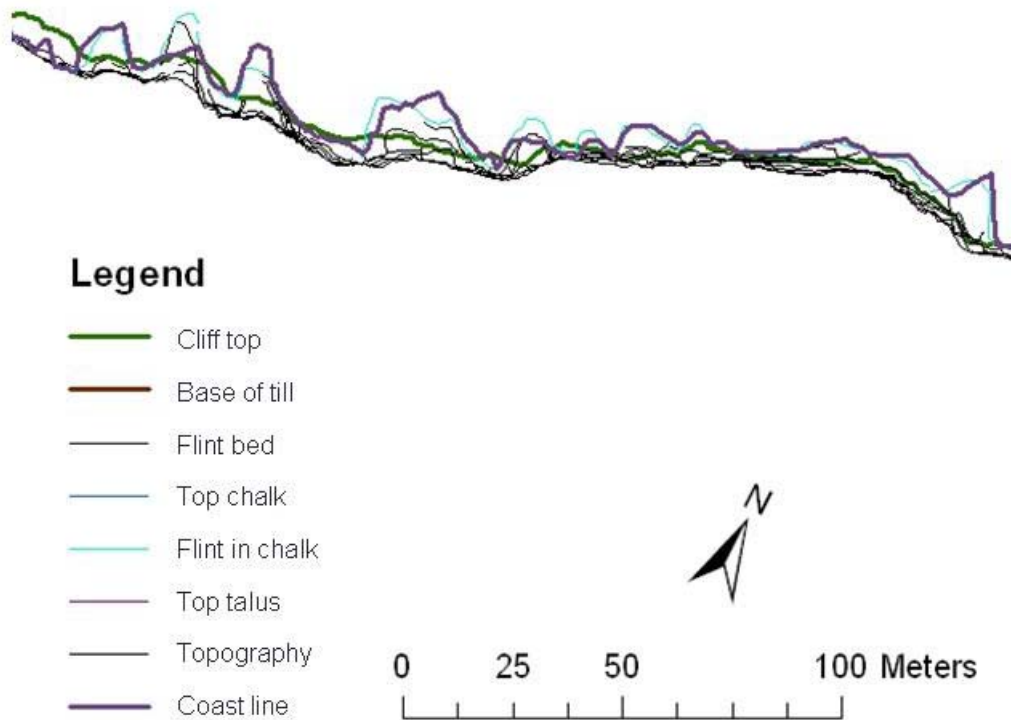


Figure 17. Photogrammetric contour map of the coastline east of Boesdal. The extension of the wave eroded caves is indicated by the tracing of the Rødvig Formation and underlying chalk marked by blue lines on the map. Note the group of thin black lines are tracings of flint bands in the limestone which represent the surface of overhanging cliff.



Figure 18. The coastline east of Boesdal is characterised by breakers erosion of caves. Note the rock-bedding exfoliation blocks present at the shoreline.

The debris shedding at Stevns Klint

The debris shedding from the cliff (Fig. 19) is just on the border of being regarded in the context of rockfall. However, the registration of the debris shedding has contributed with an important part of outlining the coastal cliff profile and it is an important part of understanding the dynamics of the background erosion. The average grain sizes of debris shedding are pebbles and cobbles and only occasionally clasts of stone-size are loosened from the cliff surface. The debris shedding is accumulated as an apron of talus along the toe of the cliff, which often is arranged as irregular cones (Fig. 20). The main cause of the debris shedding is the seasonal variation in frost and thaw during the winter time and desiccation in the dry part of the summer time, which results in the contraction and expansion that loosens pieces from the cliff. The order of erosion by debris shedding is regarded to be equal to the rate of average erosion, namely 15 cm/year.

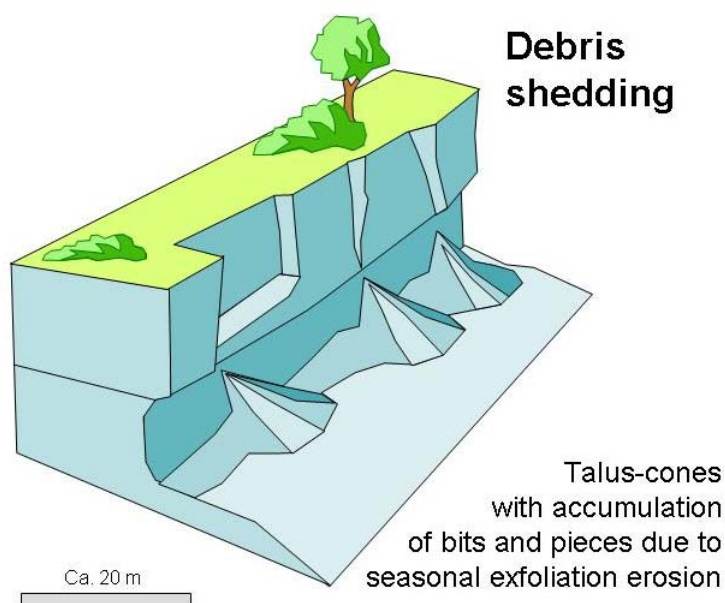


Figure 19. The general debris shedding is regarded to represent the main coarse of erosion along the coastal cliff of Stevns Klint. Compared to the rate of erosion this shedding is in the order of 15 cm/year.



Figure 20. *The general debris shedding generates small talus cones along the toe of the cliff at Stevns Klint. The photo shows the cliff section north of Holtug (Loc. 21 in Fig. 1). Note the characteristic composition of flint cobbles and stones on the foreshore.*



Figure 21. *The promontory Korsnæb is the location of the largest progradation of the coast line due to the accumulation of beach ridges along the foreshore.*

Assessment of rockfall hazards at Stevns Klint

No	Locality	Overhang	Thickness	Degree of exposure	Access	Risk
1	Korsnæb	x	xx	x	xxx	xx
2	Boesdal	xxx	xx	xxx	–	–
3	Stevnsfort S	xxx	xx	xxx	–	–
4	Stevnsfort N	xxx	xxx	xxx	–	–
5	Lille Heddinge Vig	xxx	xx	xx	x	x
6	Harvig S	xx	xx	x	x	x
7	Harvig C	xxx	xxx	xxx	xx	xxx
8	Harvig N	xx	xx	xxx	xx	xx
9	Knøsen	xx	xxx	xxx	xxx	xxx
10	Kirkevig	xx	x	xx	xxx	xx
11	Vindehuse	x	x	x	x	x
12	Stevns Fyr	xxx	xx	xxx	x	xxx
13	Tommestrup	xx	xx	x	x	x
14	Telemasten	x	x	x	x	x
15	Barmhertigheden	xx	xxx	xxx	x	xx
16	Storedal	x	x	xx	x	x
17	Sigerslev	–	–	xx	xx	–
18	Flagbanken	xxx	xxx	xx	xxx	xxx
19	Mandehoved	xx	xx	x	xxx	xx
20	Køge Bugt	xx	xx	xx	xx	xx
21	Holtug	x	x	x	xx	x
22	Holtug-Bøgeskov Havn	–	x	x	xx	–

Table 1. Schematic assessment of the risk evaluated for each of the segments along Stevns Klint. The numbers of the segments are identical to the numbers located in Fig. 1.

In the assessment analysis four important elements are considered. Most important is the size of the overhang. However, the likelihood of a collapse depends additionally on the thickness of the overhang. The shear strength and thus the point of failure for a rock is a function of the normal pressure, which corresponds to the thickness of the rock (Hobbs, Means & Williams 1976, Mandl 1988). Therefore an overhang with a thickness of 20 m is more stable than one with a thickness of only 10 m. This consideration is included in the second column

in Table 1. Thirdly the degree of exposures is also evaluated. Primarily because the exposed part of the cliff will be affected by wave erosion, and secondly because the softness of the chalk is increased by salt water spray (Mortimore et al. 2004). Finally risk will be proportional to the frequency of visitors. A detailed background for the assessment is given in the more substantial report from the Geological Survey of Denmark and Greenland written in Danish (Pedersen & Strunck 2011).

The evaluation of landslide hazard risk at Stevns Klint is based on the analysis of the rockfall processes and the magnitudes of the overhang and undercutting. The rockfalls at Stevns Klint are divided into five types according to their size and the mechanisms of transport of material from the face of the cliff to its toe. The various types of rockfalls do also occur at very different frequencies. The cliff-slides and cliff-falls are both dependant on the development of an overhang. The collapse may occur at overhang depths of 4–5 m if the bryozoan limestone is less than 3 m thick, whereas overhangs with undercutting depths up to 10–12 m may be stable if the limestone is in the order of 20 m thick. However, large overhangs suggest that future cliff-slides or cliff-falls are to be expected. The data from Højerup (Fig. 22) show that most of the recession of the cliff during the last 300 years occurred during two large cliff-slides (Rasmussen 1967). This suggests that the cliff-slides are rare events, which agrees well with the average erosion rate of 15 cm/year. At this rate it would require at least 60 years to create an overhang of 10 m (Fig. 23, 24).

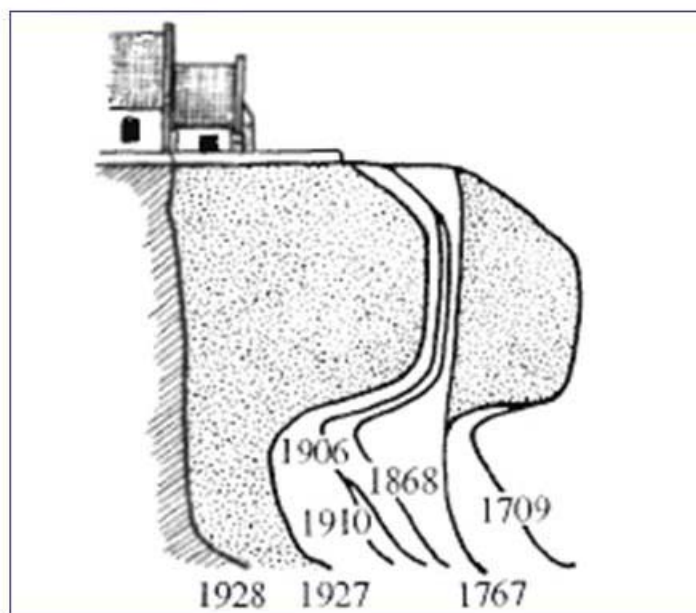


Figure 22. The recession of the cliff below Højerup old church from Rasmussen (1967). Note that the two large rockfalls occurred in 1767 and 1928. Since then the cliff below the church has been saved by coastal protection.

The parts of Stevns Klint where cliff-slides and cliff-falls may be expected are thus fairly easy to identify, although it is impossible to predict when the collapse is going to occur. In contrast, the average rockfalls and the debris shedding are more continuous processes involving significantly smaller volumes of limestone in each event. They are therefore unpredictable.

The large collapses are dangerous, but quite rare, with a likely frequency in order of one per 100 years. The more frequent rockfalls and debris shedding may theoretically pose a risk, although no recordings of injuries are known to the author. Comparison between the recent photo series and those taken 20 years ago document three rockfall along the entire cliff. This indicates that even smaller rockfalls occur with a low frequency and can not be rated as high risk hazards. The highest risk of rockfall is related to the locations of old limestone quarries along the edge of the cliff. The small thickness of the limestone between the floor of the pits and the undercutting of exposed parts of chalk cliff will promote collapses. However, some of these may be released in continuous debris shedding.

In the assessment of the risk of cliff collapse it should also be noted that certain parts of the cliff are inaccessible due to promontories and lack of foreshore. These segments of the cliff therefore pose no risk to public despite the magnitude of undercutting.

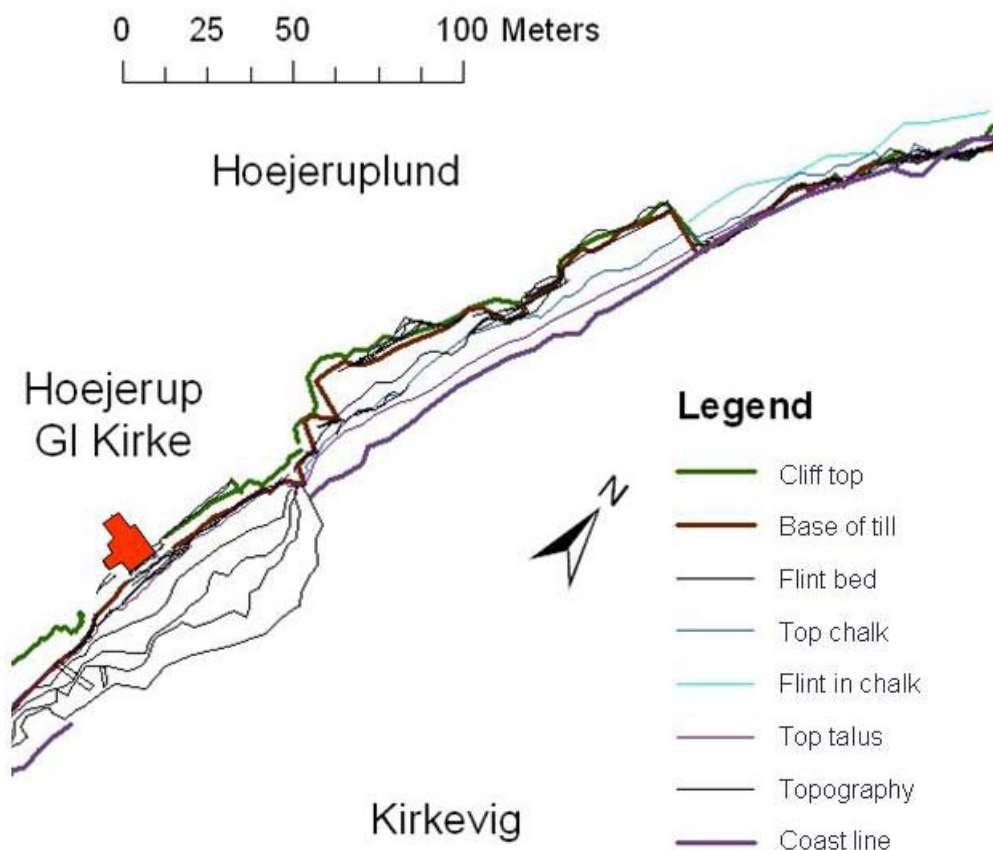


Figure 23. Photogrammetric contour map of the coastline north of Højerup old church. The overhang north of the Højeruplund limestone quarry amounts to 7–8 m. Here an overhang prone to collapse will be created within the next 25–50 years.

Conclusions

The landslide hazard assessment of Stevns Klint has been based on the investigation of rockfalls along the cliff. Five types of rockfalls are recognized ranging from cliff-slides to debris shedding. The cliff-slides have large volumes and occur at low frequencies (1/100 years). Debris shedding involves very low volumes and occurs at high frequencies (seasonal). The resulting average rate of erosion is 15 cm/year. The rockfalls involving meter-sized blocks, which include cliff-slide, cliff-fall and average rockfall, occur at frequencies of one per 10–100 years. Rockfalls may be initiated by frost and thaw, rainwater saturation or desiccation, but prediction of actual cliff collapses is at present not possible.



Figure 24. *The coastline north of Højerup old church. In the left side of the picture the traces of the limestone quarry at Højeruplund can be seen. The cliff is exposed to erosion and a hazardous overhang will probably be created within the next 50 years. Photo M. Binderup 2010.*

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The scenic coastal cliff Stevns Klint comprises the most spectacular global mass extinction event in the history of the Earth: The Cretaceous—Tertiary boundary. The mass extinction that occurred 65 million years ago is particularly spectacular due to its association with an asteroid impact and because it marks the extinction of more than half of all species, including land-living dinosaurs and large marine reptiles.

At Stevns Klint the thin, black boundary clay found in the up to 40 m high, white cliff clearly marks the abrupt fall in primary production and makes the exceptional boundary visible even to the inexperienced eye. Stevns Klint is an outstanding locality representing a major stage in Earth's history and the record of life: The mass extinction at the Cretaceous—Tertiary boundary and is nominated for inclusion for the World Heritage List.

STEVNSKLINT
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Nomination of

STEVNS KLINT

for inclusion in the World Heritage List

Appendix 6: Comparative Analysis



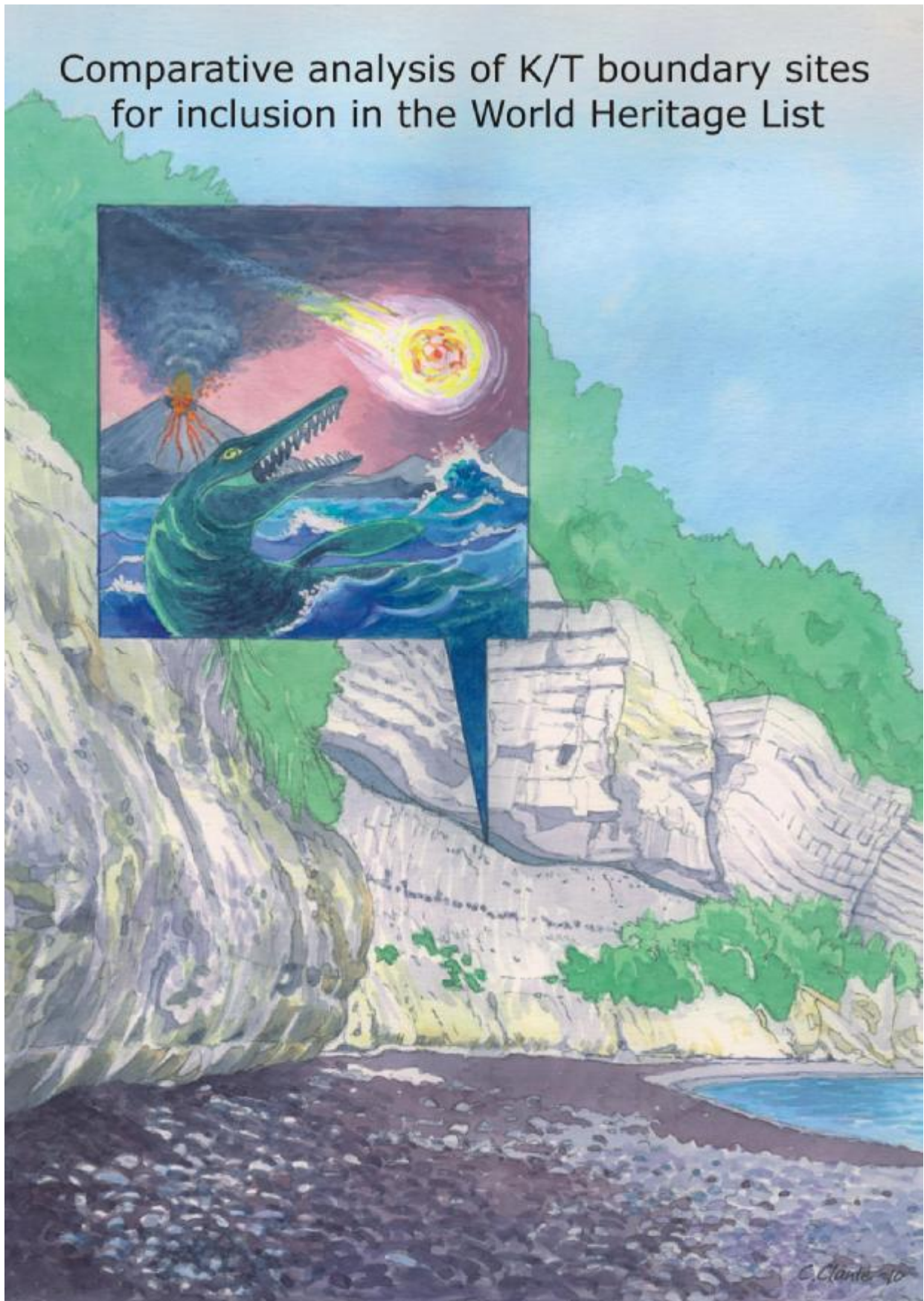
Nomination of
STEVNS KLINT

for inclusion in the World Heritage List

Appendix 6: Comparative Analysis



Comparative analysis of K/T boundary sites for inclusion in the World Heritage List



Sørensen, A.M 2010: Comparative analysis of K/T boundary sites for inclusion in the World Heritage List. Report. Østsjællands Museum.

The comparative analysis is produced in cooperation between Østsjællands Museum and Institute for Geography and Geology, University of Copenhagen, written by Dr. Anne Mehlin Sørensen and financed by the Heritage Agency of Denmark.

Scientific board: Director Tove Damholt, Østsjællands Museum and Professor Finn Surlyk, Institute for Geography and Geology, University of Copenhagen.

Professors Wolfgang Kiessling and Philippe Claeys are thanked for identifying complete K/T boundary sections and for access to information from their database on K/T boundary sections.

Preface

In 2009 The Heritage Agency of Denmark included Stevns Klint in the Danish tentative list for UNESCO World Heritage and the 8th of January 2010 Stevns Klint was officially submitted to the Tentative Lists under natural criteria viii in conformity with the Operational Guidelines.

The scenic sea cliff, Stevns Klint is located only one hours drive south of Copenhagen, the capital of Denmark. The sea cliff shows a continuous succession representing the end of the Cretaceous period through to the beginning of the Tertiary period and thus includes the boundary between the Cretaceous and the Tertiary, the so called K/T boundary with the interpreted extraterrestrial impact and associated mass extinction, 65.5 million years ago.

On advice from The Heritage Agency of Denmark, Østsjællands Museum has performed an analysis to assess criteria viii in conformity with the Operational Guidelines. The work aims to clarify if the K/T boundary event, is credible to inclusion in the World Heritage List under criteria viii, ie. if the K/T boundary can qualify as “representing major stages of Earth’s history” and to reveal which geological site worldwide is the most commendable as the “outstanding example” of the K/T boundary event as a UNESCO World Heritage Site. To ensure the highest scientific expertise the comparative analysis is performed in cooperation with the Institute of Geography and Geology, University of Copenhagen.

The comparative analysis forms a qualified basis for the coming work to ensure Stevns Klint inclusion in the World Heritage List. The further process is now in its starting phase and will be accomplished in close cooperation between the Danish Heritage Agency, Stevns Kommune, Østsjællands Museum and will include additional national and local authorities, institutions and individuals.

Tove Damholt
Director Østsjællands Museum

Contents

1. Significance of the transition from the Cretaceous to the Tertiary Period, the K/T boundary	1
2. Problems in choosing the a geological World Heritage Sites	5
3. Assessment criteria proposed for evaluating K/T boundary sites	6
3.1 <i>Main criteria to establish a short-list of sites</i>	7
3.1.1 <i>Sites meeting the three main criteria</i>	8
4. Description of K/T boundary sites meeting the main criteria	12
4.1 <i>Stevns Klint, Denmark</i>	12
4.2 <i>Nye Kløv, Denmark</i>	13
4.3 <i>El Kef, Tunisia</i>	15
4.4 <i>Elles, Tunisia</i>	17
4.5 <i>Ain Settara, Tunisia</i>	18
4.6 <i>Agost, Spain</i>	19
4.7 <i>Caravaca, Spain</i>	21
4.8 <i>Gubbio, Italy</i>	22
4.9 <i>Woodside Creek, New Zealand</i>	23
4.10 <i>Flaxbourne River, New Zealand</i>	25
4.11 <i>Mimbral, Mexico</i>	26
4.12 <i>Beloc, Haiti</i>	27
4.13 <i>Brazos River, USA</i>	29
4.14 <i>Raton Basin, USA</i>	31
4.15 <i>Hell Creek, USA</i>	33
4.16 <i>Seymour Island, Antarctica</i>	34
4.17 <i>Hokkaido, Japan</i>	35
5. Comparison and evaluation of the K/T boundary sites	36
5.1 <i>Comparative analysis</i>	36
5.1.1: <i>Fossil diversity</i>	36
5.1.2: <i>Appearance of the boundary layer</i>	37
5.1.3: <i>Lateral extent of the boundary layer</i>	38
5.1.4: <i>The degree of exposure and permanency of the site</i>	39
5.1.5: <i>Accessibility of the site</i>	40
5.1.6: <i>Degree of research on site</i>	40
5.1.7: <i>Probability of continued discoveries</i>	41
5.1.8: <i>Cumulative table of the scores</i>	42
6. Summary and conclusion	44
References	47

1. Significance of the transition from the Cretaceous to the Tertiary Period, the K/T boundary

During the Late Cretaceous period the oceans were ruled by large swimming reptiles and the land by dinosaurs. The Earth experienced greenhouse conditions associated with one of the highest known sea-level stands and shallow seas covered much of the continents (Fig. 1). Suddenly, 65.5 million years ago the Earth's ecosystems changed, the sea-level fell, the atmosphere cooled, and more than 50% of all species on Earth, including the dinosaurs, disappeared and a new era started. This extinction is one of the "Big Five" mass extinctions the Earth has experienced during the Phanerozoic – the past 550 million years. The transition from the Cretaceous to the Tertiary Period marks the end of the Mesozoic Era and the beginning of the Cenozoic Era and represents a major stage of Earth's history and a key event in the evolution of life. The transition period was associated with major global sea-level and climate fluctuations. A sea-level rise at the end of the Maastrichtian and an early Danian sea-level fall has been identified world wide. The climate changes precisely across the K/T boundary is still a unknown, mainly because the oxygen isotope records are unclear due to diagenetic alteration of carbonates (Adatte et al., 2002).

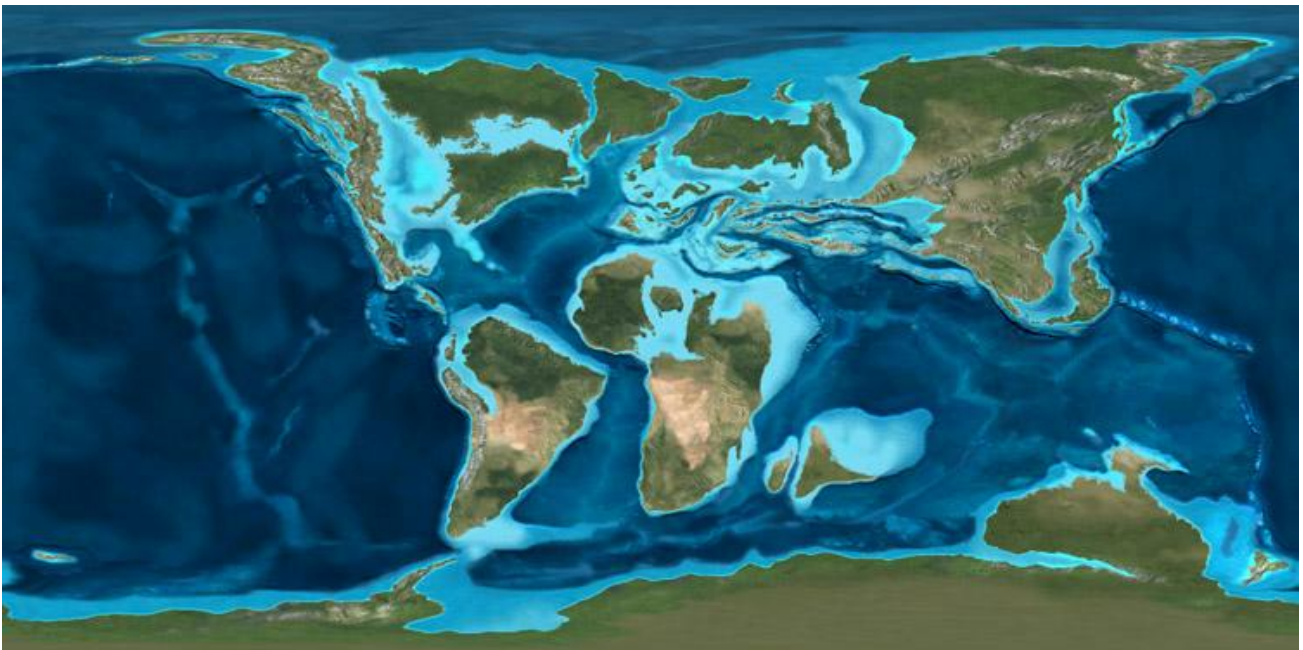


Figure 1: Palaeogeographical map of the world during the Late Cretaceous showing the high sea level stand and shallow seas covering the continents.

Much scientific work has been done on the transition from the Cretaceous to the Tertiary Period since it represents the only known mass extinction and change of the global ecosystems which has been related to an extraterrestrial impact. The discovery of an iridium anomaly, Ni-rich spinel, a mineral formed by fusion and oxidation in the atmosphere of meteoritic objects, and shocked quartz grains in the Cretaceous/Tertiary (K/T) boundary layers around the world formed the basis for the hypothesis of an enormous asteroid impact causing the mass extinction. The Chicxulub crater in Mexico (ca 200 km in diameter) is the best candidate for a K/T impact site (Hildebrand et al., 1991, Dupuis et al., 2001; Hollis, 2003). After almost 30 years of intensive research, debate and controversy about what caused the anomalous high iridium concentrations and the mass extinctions recorded in many floral and faunal groups at the K/T boundary, the Alvarez impact hypothesis (Alvarez et al., 1980) has been widely accepted. Other events, such as major volcanic activity releasing large amounts of ashes and gasses and major sea-level changes, have also been suggested as a cause for the mass extinction (Keller 1988 a, b, 1993, 2003; Smit, 1999; Dupuis et al., 2001; Gallagher, 2002; Hollis, 2003).

It is known that the mass extinction is closely linked to the impact event but it is still not clear how the impact event is linked to the extinctions. Alvarez et al. (1980) originally suggested that an extraterrestrial impact would leave a dust cloud in the stratosphere for several years, resulting in darkness on Earth. The temporary absence of sunlight would shut down photosynthesis followed by a food chain collapse and in combination with a prolonged period (> 3 kyr) of global warming it could explain most of the biotic events. The pattern of extinction and survival across the K/T boundary does provide a model for a collapse of the marine ecosystems generated by large-scale environmental disturbance (Smit, 1999; Gallagher, 2002).

The great majority of K/T boundary sections are located in the marine environments and most complete K/T boundary successions were deposited in the deep sea and thus accessible only through drilling programs which, in most cases, excludes information about microfossils (Ward et al., 1986; Kiessling and Claeys, 2001). Microfossils have therefore primarily been used for investigating the nature of the mass extinction, the global change around the K/T boundary, and the recovery patterns. Especially planktonic foraminifers has been used since they are sensitive of environmental changes such as shifts in water temperatures, salinity, oxygen, nutrients, and water depth and generally are abundant in relative shallow to deep marine environments across latitudes (Canudo et al., 1991; Luciani, 2002).

The K/T boundary Global Stratotype Section and Point (GSSP) was officially defined at the El Kef section in Tunisia at the base of the boundary clay layer anomalously rich in iridium. The GSSP is an instant in time represented by this bedding plane. All other criteria such as mass-extinction level, last occurrence of Maastrichtian fossils, first occurrence of Paleocene fossils, iridium anomaly, Ni-rich spinels, soot, and negative shift of $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ are closely associated and can be used for correlation but are not part of the K/T boundary definition (Smit, 1999). Criteria which can be used for identifying the K/T boundary in terrestrial sites are the abrupt disappearance of numerous species of plant microfossils; the presence of an iridium anomaly, and the presence of shocked mineral grains, primarily quartz (Nichols, 2007).

The K/T boundary coincides with one of the most pronounced faunal turnovers known in the geological record, a turnover that affected both terrestrial and marine faunas, leading to the life we know on Earth today. It represents the only change of the global ecosystems and a mass extinction which has been related to an extraterrestrial impact, and the K/T boundary event therefore represents a major event in Earth's history and in the evolution of life. Even though it is an important period of the Earth's History the Cretaceous/Tertiary transition is not yet represented by a UNESCO World Heritage Site.

Geological sites, which are already inscribed as a UNESCO World Heritage Site represents different periods of geological time including the Cambrian (Burgess Shale), Ordovician (Gros Morne), Devonian (Miguasha National Park), Carboniferous (Mammoth Cave, Joggins Fossil Cliffs), Permian (Grand Canyon), Mesozoic (Dorset and East Devon Coast), Triassic (Talampaya Natural Parks, Monte San Giorgio), Cretaceous (Dinosaur Provincial Park), Eocene (Messel Pit, Wadi Al-Hitan), Miocene (Riversleigh), and Recent (Naracoorte) (Fig.2).

The aim of this comparative study is to document that the nominated K/T boundary site, Stevns Klint, is the very best and most outstanding site to present the unique record of the geological significant Cretaceous–Tertiary boundary interval.

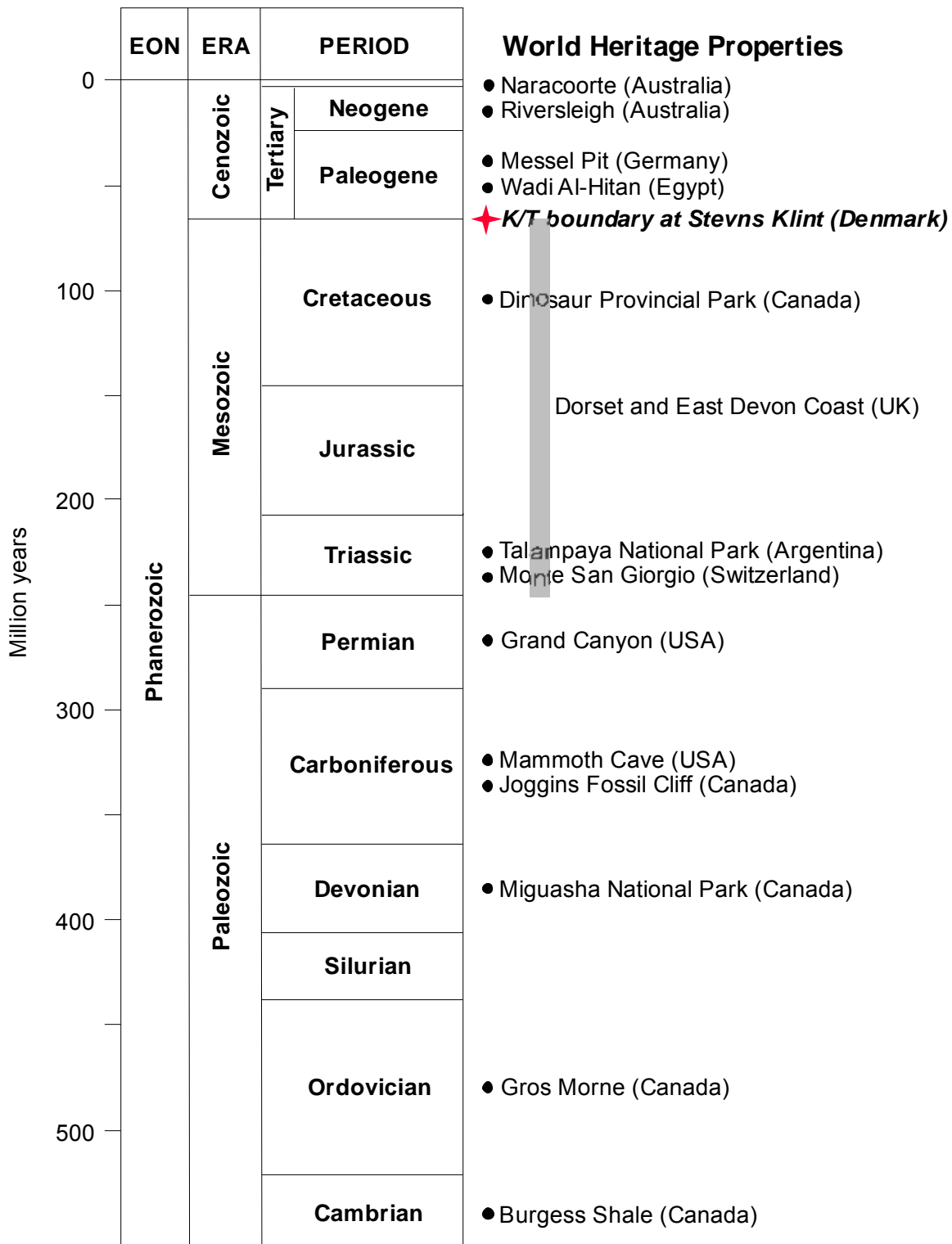


Figure 2: Stratigraphic scheme showing the major time intervals of the Phanerozoic Era and the geological interest of the K/T boundary at Stevns Klint in relation to the age of geological sites inscribed on the World Heritage list. The Stevns Klint site is written in bold and italics.

2. Problems in choosing a geological World Heritage Sites

Dorset County Council (2000) and Falcon-Lang (2002) explained in their comparative analysis of Mesozoic and Pennsylvanian fossil sites, respectively, the problems in attempting to choose a single geographical site as representative of a period of geological time. One problem is that the Earth today exhibits great variability in its environments and ecosystems and has done so throughout its history. It may be a problem to compare marine and terrestrial sections since the fossil contents and lithologies are very different. The fundamental nature of a nomination is thus the character of the nominated site as comprising a whole assemblage of significant features. Together these features result in a resource, which is both of global importance to the Earth Science, and lies within a beautiful and accessible setting.

The K/T boundary interval represents a stratigraphic site, showing the evolution of life before and after a mass extinction and not a fossil site where the surrounding environment plays a significant role. In this comparative study all environmental settings are thus included and all sites which meet the main criteria are compared.

3. Assessment criteria proposed for evaluating K/T boundary sites

The nominated K/T boundary site is considered as having outstanding universal value by meeting the criterion viii from the "Operational Guideline" to the World Heritage Convention which states that "Nominated properties shall be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features". Within criterion viii the IUCN recognises four different natural elements relevant to geological and geomorphological science (Dingwall et al., 2005). These are: Earth's history; The record of life; Significant on-going geological processes in the development of landforms; Significant geomorphic or physiographic features. The nominated K/T boundary site belongs to Earth's history which is defined by IUCN as a subset of geological (as opposed to geomorphological) features which are represented by phenomena that record important events in the past development of the planet such as:

- The record of crustal dynamics and tectonism, linking the genesis and development of mountains, volcanoes, plate movements, continental movement and rift valley development.
- Records of meteorite impacts.
- Records of glaciations in the geological past.

Sites in this category would be of outstanding universal value in the exhibiting elements of Earth history through rock sequences or association rather than fossil assemblages (Dingwall et al., 2005). Furthermore, thirteen geological themes, under criteria viii, are proposed by Dingwall et al. (2005) (Appendix A) and of these, the nominated K/T boundary site fits into proposal 4, stratigraphic sites, and 13, meteorite impact. Until now (2009) three stratigraphic sites are inscribed, the Grand Canyon National Park, Dorset and East Devon Coast, and Joggins Fossil Cliffs, and one meteorite impact site, the Vredefort Dome, is inscribed. The Vredefort Dome meteorite impact site represents an actual impact crater. No inscribed sites represent the physical evidence of meteorite impact together with the major changes that have resulted from the impact which can be recognised through a stratigraphic site such as the K/T boundary succession at Stevns Klint.

Criteria for selecting palaeontological World Heritage sites have been presented in different publications (Cloutier and Lelièvre, 1998; IUCN, 1994; Well, 1996). Not

all these are relevant for evaluating K/T boundary sites since they were primarily developed for fossil sites of a very different nature. Falcon-Lang (2002) presented some considerations of these criteria, in the comparative analysis of Pennsylvanian fossil sites, and ended up subdividing the World Heritage Site criteria into three categories.

1. *Fossil record of biodiversity*

The site should contain abundant fossil specimens and a large number of species, which represents the broadest possible range of major taxonomic groups.

2. *Nature, quality and variability of fossil archive in the rock section itself*

The time interval represented by the sites; is it a "snapshot" of an ecosystem or million years of history?. Sites where ecosystems are preserved over a sustained time period are to be preferred, because they will likely better record the typical range of ecosystems types, and the community's dynamic response to changing environments and climates. Sites should encompass the greatest variety of depositional environments to paint the broadest picture of the world at a particular time interval. The sites should record aspects of the palaeobiology of the ecosystems for example evidence concerning food chains (such as coprolites or bite marks). The sites should additionally have a good fossil preservation quality.

3. *Permanency (integrity) and scientific impact of site*

Significance of the site itself. One subject is to which degree the site has been investigated and discoveries curated. Another item is that geological sites continuously under natural erosion (e.g. sea-cliffs) are to be preferred over artificial excavations because they are of greater permanency and are most likely to continuously yield new fossils in the future.

These three categories, representing previous criteria for selecting palaeontological World Heritage sites, will be used in the comparative analysis of K/T boundary sites to include all formerly used criteria for geo-sites.

3.1 *Main criteria to put up a short-list of sites*

Since there are more than 500 known K/T boundary sites around the world (Kiessling and Baron-Szabo, 2004) three main criteria are put together to produce a short list of K/T boundary sites for the comparative analysis. Only sites that meet these criteria are described in greater detail.

Main criterion 1. The succession should be complete across the boundary representing the latest Cretaceous and the earliest Danian to represent the entire event, the nature of the mass extinction, and the subsequent recovery of life after the extinction.

Main criterion 2. The potential K/T boundary sites should be well studied and described, allowing comparison.

Main criterion 3. Since the K/T boundary represents an impact event, the site should include the presence of a boundary layer enriched in iridium and other elements considered to be mainly or partly of meteoritic origin. The boundary layer should be lithologically different from the underlying Cretaceous sediments and the overlying Danian sediments.

These three criteria makes sure that sites used for the comparative analysis tell the complete story of the extraterrestrial impact and the time-equivalent extinction by the presence of impact traces in the boundary layer and the presence of both Cretaceous and Danian sediments to prove the faunal turnover across the K/T boundary.

3.1.1 Sites meeting the three main criteria

Details about more than 500 K/T boundary sites around the world have been collected in a comprehensive database (KTbase) designed to evaluate the causes and mechanisms of the K/T boundary event (Kiessling and Claeys, 2001; Kiessling and Baron-Szabo, 2004). The KTbase is not public assessable but Professor Wolfgang Kiessling filtered the database and recorded 43 boundary sites which are exposed sections (ODP sites were excluded), complete across the boundary, includes the presence of a boundary layer enriched in iridium and other elements, and provide good data quality (Table 1). The 43 sites together with eight well known, possibly complete localities were tested for their scientific impact by making searches of K/T, C/P or K/P together with the locality name on the standard databases Web of Science and GeoRef (Table 1). Of the 51 K/T boundary sites analysed for scientific impact, 17 sites turned out to be well described with more than 10 scientific papers in either of the databases (Table 1). The 17 sites do all have a boundary layer which is lithologically different from the underlying Cretaceous sediments and the overlying Danian sediments and is enriched in iridium. These 17 K/T boundary sites are therefore used for the comparative analysis of potential K/T boundary sites (Table 2). The 17 sites are distributed in

13 countries and on six continents, only missing a site on the South American continent (Fig. 3).

Table 1: K/T boundary sites which are complete across the boundary. The table show the scientific impact of each site found on the online databases; web of Science and GeoRef. The impact is found by searching for K-T, K-P or C-P together with the site name. Only the highest impact found on either Web of Science or GeoRef are listed.

K/T boundary sites	Country	Scientific impact
El Kef	Tunesia	97
Stevns Klint	Denmark	53
Hell Creek	USA, Montana	53
Caravaca	Spain	45
Raton Basin	USA, New Mexico	25
Brazos River	USA, Texas	24
Beloc	Haiti	22
Mimbral	Mexico	22
Geulhemmerberg	Netherlands	22
Agost	Spain	22
Gubbio	Italy	19
Hokkaido	Japan	17
Nye Kløv	Denmark	11
Seymour Island	Antarctica	11
Elles	Tunesia	11
Flaxbourne River	New Zealand	11
Ain Settara	Tunesia	11
Woodside Creek	New Zealand	10
Zumaya	Spain	8
Koshak	Kazachstan	6
Sopelana	Spain	3
Poty, Paraiba Basin	Brazil	6
Moody Creek	New Zealand	2
Kjølby Gaard	Denmark	2
Lattengebirge	Germany	2
Sumbar	Turkmenistan	2
Erto	Italy	2
Actela	Guatemala	2
Herrera	Spain	2
Dania	Denmark	1
Rotwandgraben	Austria	1
Malyi Balkhan	Turkmenistan	1
Gamba	China	1
Millers Ferry	USA, Alabama	1
Trinitaria	Mexico	1
Moscow Landing	USA, Alabama	1
Canon San Fernando	Mexico	1
Via Perimetral	Equador	0
Urrutzua	Spain	0
Irurtzun	Spain	0
Matisgraben	Switzerland	0
Elendgraben	Austria	0
Rio Minho	Jamaica	0

Table 2: K/T boundary sites meeting the main criteria, their palaeoenvironments, palaeolatitudes, and current locations.

K/T boundary sites	Country	Scientific impact	Environment / depth	Palaeolatitude	Location
El Kef	Tunesia	97	Upper bathyal 300–500 m	ca. 25° N	Valley
Stevns Klint	Denmark	53	Epicontinental sea 100–200 m	ca. 50° N	Coastal cliff
Hell Creek	USA, Montana	53	Terrestrial		Valleys
Caravaca	Spain	45	Middle bathyal 600–1000 m	ca. 30° N	Valley
Raton Basin	USA, New Mexico	25	Terrestrial		Road cut
Brazos River	USA, Texas	24	Middle–outer shelf < 100 m	ca. 30° N	River bank
Beloc	Haiti	22	Deep marine 1500–2000 m		Road cut
Mimbral	Mexico	22			Stream bank
Agost	Spain	22	Middle bathyal	ca. 30° N	Road cut
Gubbio	Italy	19	Lower bathyal 1500–2500 m	ca. 35° N	Road cut
Hokkaido	Japan	17	Upper bathyal (300–600 m) shallowing to 150–300 m	ca. 50° N	Stream bank
Nye Kløv	Denmark	11	Inner neritic	ca. 50° N	Abandoned quarry
Seymour Island	Antarctica	11	Shallow mid shelf	ca. 65° S	Valleys and coastal cliff
Elles	Tunesia	11	Middle to outer neritic shelf	ca. 25° N	Valley
Flaxbourne River	New Zealand	11	Mid-bathyal		Quarry
Ain Settara	Tunesia	11	Middle to outer neritic shelf	ca. 25° N	Along a channel
Woodside Creek	New Zealand	10	Upper bathyal		Creek



Figure 3: Sketch map showing locations of K/T boundary sites meeting the general criteria. 1: Stevns Klint, 2: Nye Kløv, 3: Agost, 5: Caravaca, 6: El Kef, 7: Elles, 8: Ain Settara, 9: Hell Creek, 10: Raton Basin, 11: Brazos River, 12: Mimbral, 13: Beloc, 14: Seymour Island, 15: Flaxbourne River, 16: Woodside Creek, 17: Hokkaido

4. Description of K/T boundary sites meeting the main criteria

4.1 Stevns Klint, Denmark – Marine section

Geographic description of the site

The Stevns Klint site is located about 45 km south of the Danish capital, Copenhagen on the east coast of the Danish island of Sjælland. The site comprises a 14.5 km long coastal cliff which can be easily reached by taking road 261 from Strøby Egede to Rødvig where access can be made from different places along the road.

Lithology and palaeoenvironment

The site is 14.5 km long and the exposed succession is up to 41 m thick. The lower parts of the cliff expose upper Maastrichtian chalk with bryozoan chalk wackestone at the top outlined by thin layers of nodular flint. The chalk is overlain by the K/T boundary clay, the Fish Clay, which is generally about 5–10 cm thick and enriched in iridium. The position of the boundary layer varies from about 5 m below to about 30 m above present day sea level. The irregular relief represents a depositional sea-floor topography (Lykke-Andersen and Surlyk, 2004). The Fish Clay passes gradually upwards into the strongly burrowed lowermost Danian Cerithium Limestone. A hardground surface truncates the top of the Cerithium Limestone and the intervening crests of the uppermost Maastrichtian mounds. This surface is overlain by lower Danian bryozoan limestone mounds outlined by thick black flint bands which illustrates the geometry, dimensions and architecture of one of the finest cool-water carbonate mound complexes in the world (Surlyk et al., 2006).

Fossil content

The site contains a rich and varied microbiota of foraminifers, dinoflagellates, and calcareous nannofossils. It is one of the few K/T boundary sites where the macrofauna is diverse and well preserved, comprising bivalves, echinoids, brachiopods, solitary corals, bryozoans, polychaetes, gastropods, asteroids, sponges, crinoids, tracefossils, and vertebrate remains.

Significance of the site

The beautiful coastal cliff Stevns Klint is one of the most famous, scenic and best exposed K/T boundary sites in the world where the exceptional K/T boundary layer is easily recognised just beneath the topographic overhang of the younger and

harder Tertiary limestone. It is a classical K/T boundary site and constitutes the type locality of the Danian Stage. It is one of the three discovery localities of the famous iridium anomaly, which formed the basis for the asteroid impact hypothesis of Alvarez et al. (1980) to explain the mass extinction at the end of the Cretaceous. Stevns Klint is therefore a key locality in the ongoing debate about the K/T boundary and international researchers have flocked to Stevns Klint to sample the famous iridium-rich boundary clay. It is also visited by numerous student excursions, school classes and tourists every year. Furthermore, the Stevns Klint site shows an excellent exposure of one of the finest examples in the world of a cool water, sub-photic carbonate mound complex (Surlyk et al., 2006).



Figure 4: The K/T boundary at Stevns Klint immediately beneath the overhang at the middle of the cliff (Photo: Anne M. Sørensen).

4.2 Nye Kløv, Denmark – Marine section

Geographic description of the site

The Nye Kløv site is located in a small abandoned chalk quarry with an average dimension of 40 m in length and 20 m in height. The quarry is situated few kilometres north of Lønnerup Fjord in the northern part of Jylland (Johansen, 1987). The exposure is at present covered by talus and it is necessary to excavate a trench to locate the boundary.

Lithology and palaeoenvironment

The exposed site across the K/T boundary is about 20 m thick, including 8 m of Maastrichtian and 12 m of Danian chalk. The Maastrichtian sediments consist of white chalk with scattered flint nodules and macrofossils. The K/T boundary is marked by a 3 cm thick brownish-grey marly clay with rust at its base and an enrichment in iridium. The Danian sediments consist of 0.5 m thick greyish marly chalk layer topped by 8.5 m white bryozoan limestone, containing as much as 25 wt % bryozoans, interbedded with 10 to 20 cm thick flint nodule layers (Johansen, 1987). Macrofossils in the bryozoan limestone increasing in abundance and diversity upwards (Håkansson and Hansen, 1979; Surlyk and Johansen, 1984).

Fossil content

The site contains microbiota of dinoflagellates, foraminifers, and calcareous nanofossils. Furthermore, it is one of the few K/T boundary sites where the macrofossils are well preserved and contains bryozoans, echinoids, bivalves, brachiopods, and trace fossils (Surlyk and Johansen, 1984; Johansen, 1987; Keller et al., 1993; Kiessling and Claeys, 2001)

Significance of the site

The Nye Kløv site is one of the few complete K/T boundary sites with a high quality record of the K/T extinction pattern for macrofossils.



Figure 5: The K/T boundary at Nye Kløv is exposed behind people in each side of the site (Photo: Anne M. Sørensen).

4.3 El Kef, Tunisia – Marine section

Geographic description of the site

The El Kef site is located 7 km west of the town of El Kef. The site is reached by taking an unpaved road leading to the village of Hamman Mellégue located near the site. About 2 km along this unpaved road is a small cement water reservoir overlooking a large valley formed in Maastrichtian to Eocene limestones and marls. From this location the K/T boundary site can be found by descending into the valley for about 1.5 km on a gentle slope within the soft grey marl of the El Haria Formation (Keller et al., 1995).

Lithology and palaeoenvironment

The K/T boundary site of El Kef is contained within the El Haria Formation. The Maastrichtian sediments consist of relative carbonate rich grey marl with about 40% CaCO₃ and with common burrows about 2–3 cm long (Keller, 1988b). The K/T boundary is marked by a 50 cm black, organic-rich clay layer with about 3–4% CaCO₃ and an overlying 50–60 cm marly clay layer with about 10% CaCO₃. A 2–3 cm oxidised thin rust-red layer at the base of this clay unit marks the boundary event and define the K/T boundary. The thin rust-red layer shows a drop in CaCO₃, a maximum of organic carbon, and a negative excursion in $\delta^{13}\text{C}$. It contains the iridium anomaly and other impact evidence such as the Ni-rich spinels, shocked quartz grains, Os anomaly and spherules of sanidine and hematite (Arenillas et al., 2000). The red layer is continuous and can be followed over several hundred metres (Abdelkader et al., 1997). No burrows are observed through the red layer or in the black clay (Keller, 1988b). The Danian sediments consist of relatively carbonate rich grey marls with about 40% CaCO₃. The upper Maastrichtian – Danian succession is more than 500 m thick and consist predominantly of hemipelagic calcareous marls with few micritic limestone intervals. Obvious breaks in sedimentation or hardgrounds are absent in the entire interval (Smit, 1999)

Fossil content

The site contains a rich and varied microbiota of foraminifers, ostracods, coccoliths, and dinoflagellate cysts but spores and pollen from the hinterland are also found. Insignificant amounts of macrofossils, mainly echinoids, inoceramid bivalves, and ammonites are found, whereas tracefossils are abundant. The absence of bioturbation across the boundary makes a very precise biostratigraphic study possible (Abdelkader et al., 1997; Smit, 1999).

Significance of the site

The El Kef site was officially designated the K/T boundary global stratotype site and point (GSSP) in 1989 at the 28th International Geological Congress in Washington (Arenillas et al., 2000). The selection is based on the abundant presence of well-preserved microfossils and the unusually complete and expanded sedimentary succession where the litho- and biostratigraphic units used to recognise the K/T boundary are thicker than in other pelagic sites (Dingus, 1984). Furthermore, the absence of bioturbation and the high sedimentation rate in quiet conditions preserve a high resolution record of the K/T transition where hiatuses have not been identified (Abdelkader et al., 1997). Due to selection to the global stratotype site and point for K/T boundaries the El Kef stratotype is endangered by oversampling and on top of this agricultural encroachment also threat the site (Karoui-Yaakoub et al., 2002).



Figure 6: The K/T boundary at El Kef

(From: http://images.google.com/imgres?imgurl=http://www.panoramio.com/photos/original/12358292.jpg&imgrefurl=http://www.panoramio.com/photo/12358292&usq=_fY7fJJf-r0u8AtK3n-U4dbE-dD8=&h=1200&w=1600&sz=1533&hl=fr&start=4&itbs=1&tbnid=TFf8kmSOKdH8sM:&tbnh=113&tbnw=150&prev=/images%3Fq%3DKT%2Bboundary%2Bel%2Bkef%26gbv%3D2%26hl%3Dfr).

4.4 Elles, Tunisia – Marine section

Geographic description of the site

The Elles site is located 75 km southeast of the El Kef GSSP site in a valley near the small town of Elles. The site is reached by driving about 7 km along an unpaved road leading to the village of Elles where a wide, ca. 4 km long valley begins. The valley is cut by the usually dry Karma River. The valley continuously exposes sediments spanning from the Campanian to the lower Eocene. The K/T boundary outcrops in numerous places and can be traced over hundreds of metres along the slopes of the valley. The location of the K/T boundary is based on the same lithological changes and planktonic foraminiferal extinctions and evolutions as at the El Kef stratotype (Karoui-Yaakoub et al., 2002).

Lithology and palaeoenvironment

The Maastrichtian succession consists of grey shales and several thin marly limestone layers. The K/T boundary is well marked by a 5–30 cm thick bioclastic packstone. Above this layer is a 0.5–1.0 cm thick clay layer followed by a 3–4 mm thick rust-red layer associated with two thin gypsum layers. This red layer marks the K/T boundary event and contains altered spherules, Ni-rich spinels and maximum concentrations of iridium. The red layer is overlain by a 50–60 cm thick dark grey to black clay layer followed by 6 m of gradually lighter coloured clayey shales. The Danian succession consists of 7.5–12 m grey shales interbedded with several thin marly limestone layers, overlain by another 8 m of marly shales which grade into interbedded limestone and marl layers (Karoui-Yaakoub et al., 2002)

Fossil content

The site contains a rich and varied microfauna and nannoflora, including foraminifers, ostracods and coccoliths. No macrofossils are recorded from the Elles site around the K/T boundary.

Significance of the site

The Elles site is complete with all the indicated foraminifer zones and subzones being slightly more expanded than elsewhere. The Elles site thus exposes a better K/T interval outcrop compared to the El Kef site. This supports the proposal of the Elles site to be designated as a new stratotype or at least parastratotype (Zaghib-Turki et al., 2001). Furthermore, due to the many outcrops oversampling is not a concern, like at El Kef, and there is no danger of destruction due to agricultural encroachment because of the steep valley slopes (Karoui-Yaakoub et al., 2002).

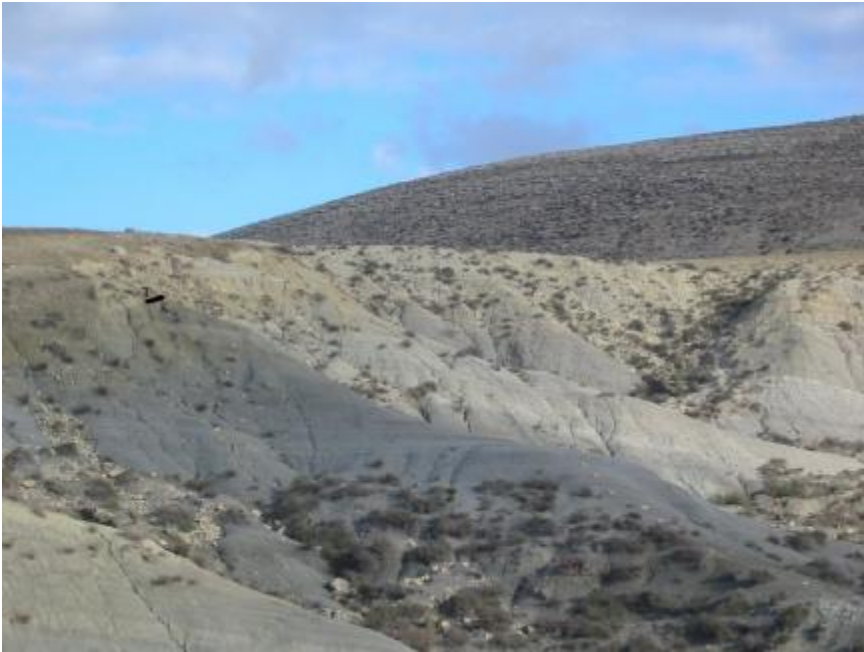


Figure 7: The K/T boundary at Elles (Photo: Nicolas Thibault)

4.5 Ain Settara – Marine section

Geographic description of the site

The Ain Settara site is located in the Atlas Mountains about 50 km southeast of the El Kef site. The K/T boundary is exposed in the 100 m high, very steep flank of a deeply incised gully at about 80 m above the base of the gully. The boundary can be traced horizontally over more than 200 m. The exposure of the boundary is excellent since there is almost no vegetation on the steep slope (Dupuis et al., 2001; Luciani, 2002).

Lithology and palaeoenvironment

The uppermost Maastrichtian succession consists of grey silty marls with a strongly burrowed upper boundary and carbonate content of 35–45%. Few bivalves, brachiopods, and solitary corals occur at about 14 cm below the top of the marls. The K/T boundary is marked by a thin dark clay layer with a 0.5 cm thick red oxidized layer at its base containing maximum iridium concentrations and Ni-rich spinels. The entire dark boundary clay is about 60 cm thick with a carbonate content of 4–5% which increases upwards to about 5–20%. The Danian succession consists of light grey marl with a marked upward increase in carbonate content to 35% (Dupuis et al., 2001; Luciani, 2002).

Fossil content

The site contains a rich and varied microfauna including foraminifers, calcareous nannofossils, and dinoflagellate cysts and invertebrates such as bivalves, brachiopods, and solitary corals (Dupuis et al., 2001).

Significance of the site

The Ain Settara site is more complete in the uppermost Maastrichtian than the El Kef site (Dupuis et al., 2001).

4.6 Agost, Spain – Marine section

Geographic description of the site

The Agost site is located about 1 km north of the village of Agost in the Alicante provins, in SE Spain ca. 100 km east of the Caravaca K/T boundary site. The K/T boundary is well exposed along a roadcut near the 13 km marker post of the Agost-castalla road (Molina et al., 2005).

Lithology and palaeoenvironment

The Maastrichtian succession consists of grey marls, interbedded with marly limestones; the latter are very scarce in the uppermost Maastrichtian. The K/T boundary is marked by a 12 cm thick layer of black clay, with a 2–3 mm thick, red layer at its base. The red layer marks the K/T boundary and contains spherules, Ni-rich spinels and maximum concentrations of iridium. Furthermore, it contains goethite, hematite, glauconite clasts, scarce foraminifers and a sharp decrease in carbonate content compared to the immediately underlying beds. The black clay is overlain by a 10 cm thick layer of massive grey clay. The Danian succession consists of two decimetre-thick tabular bodies of marly limestones with a decimetre-thick intercalated layer of marls. The upper part of the site consists mainly of marly limestones. Trace fossils are abundant across the boundary (Molina et al., 2005).

Fossil content

The site contains a rich and varied foraminiferal and ostracod fauna, nannofossil cocclith flora and insignificant amounts of macrofossils, mainly echinoids, inoceramid bivalves, ammonites, and abundant tracefossils (Smit, 1999; Molina et al., 2005).

Significance of the site

The Agost section is one of the most continuous and expanded K/T boundaries in the Tethys region and is therefore considered a classical K/T boundary site which has been studied from different points of view, such as micropaleontology, paleoichnology, magnetostratigraphy, mineralogy, and geochemistry (Molina et al., 2005). The site is exposed in a roadcut where the succession is tilted and the K/T boundary can therefore only be studied in a limited area.



Figure 8: The K/T boundary at Agost. Top: General view of the uppermost Cretaceous and lower Tertiary. Left: Detail of the lower Danian dark clay layer. Right: Detail of the red rusty layer at the K/T boundary (From Molina et al., 2005).

4.7 Caravaca, Spain – Marine section

Geographic description of the site

The Caravaca site is located 4 km SE of the village of Caravaca and about 100 km west of the Agost site in SE Spain.

Lithology and palaeoenvironment

The site belongs to the Jorquera Formation (lower Maastrichtian – lower Danian), which is about

225 m thick and made up of intercalated marls, marly limestones and occasional turbidites. No turbidites are present from 1 m below to 2 m above the K/T boundary (Canudo et al., 1991). The Maastrichtian succession consist of marlstones. The K/T boundary is well marked by a dark 7–10 cm thick dark clay layer which has a sharp decrease in carbonate from 80% in the immediately underlying bed to 20%. A 1–2 mm thick rust-red layer is found at the base of the clay and contains maximum concentrations of iridium and spherules. The Danian sediments consist of marlstones (Robin et al., 1991; Arinobu et al., 1999).

Fossil content

The site contains a rich and varied foraminifer fauna and nannofossil coccolith flora and insignificant amounts of macrofossils, mainly echinoids, inoceramid bivalves, ammonites, and abundant trace fossils (Smit, 1999; Rodríguez-Tovar and Uchman, 2006).

Significance of the site

The Caravaca site is characterized by high completeness, probably preserving sediment during each 10,000 yr interval of chron 29R, as well as an exceptional foraminifer record (Dingus, 1984; Rodríguez-Tovar and Uchman, 2006).

Unfortunately urban and road-building development has threatened the excellent exposures, and the lower 100 m of the upper Maastrichtian are already not longer accessible (Smit, 2004).

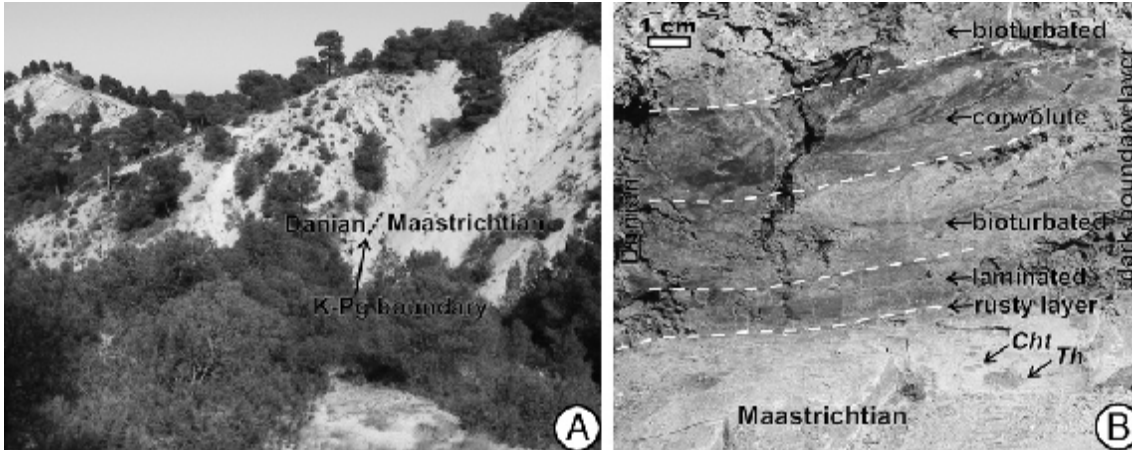


Figure 9: The K/T boundary at Caravaca (A) View of the eastern slope of the valley, where the boundary is located. (B) The dark boundary layer with its subdivisions; *Chondrites targionii* (Cht) and *Thalassinoides* (Th) in cross-site (From Rodriguez-Tovar and Uchman, 2006).

4.8 Gubbio, Italy – Marine section

Geographic description of the site

The Gubbio site is located within 1 km north of the town of Gubbio along the road to Scheggia in the Bottaccione Gorge in the Umbria-Marche Apennines, central Italy (Arthur and Fisher, 1977; Cronholm and Schmitz, 2007).

Lithology and palaeoenvironment

The K/T boundary site of Gubbio is contained within the Scaglia Rossa Formation which consists predominately of pink to red homogeneous limestone and marly limestone that have been thoroughly bioturbated and compacted prior to cementation (Cronholm and Schmitz, 2007) The limestones generally contain about 5% clay. The K/T boundary is marked by a 1–2 cm thick dark clay layer and is further marked by a 20–50 cm thick zone of white bleached limestone underlying the clay (Alvarez et al., 1980; Cronholm and Schmitz, 2007). The boundary clay is enriched in iridium and contains about 50% CaCO₃ but this is coarse-grained calcite that probably crystallised during deformation long after deposition (Alvarez et al., 1980).

Fossil content

The site comprises a rich foraminifer fauna and calcareous nannofossils.

Significance of the site

The Gubbio site is one of the three classic discovery locations for the of the iridium anomaly (Alvarez et al., 1980). The succession is tilted and the K/T boundary can therefore only be studied in a limited area.



Figure 10: The K/T boundary at Gubbio. The boundary layer is located in the deep fissure (Photo: Anne M. Sørensen)

4.9 Woodside Creek, New Zealand – Marine section

Geographic description of the site

The Woodside Creek site is located in the eastern Marlborough on the northern South Island of New Zealand and can be reached by a 15 minute walk up the creek, past some patchy outcrops of Eocene mudstone. The K/T boundary is exposed on both banks about 50 m into the gorge and is easily recognised by the many drill holes from a palaeomagnetic study.

Lithology and palaeoenvironment

The Maastrichtian succession consists of 30 m of light green-grey, bedded, siliceous limestone with thin marl interbeds. The K/T boundary is marked by a 25 mm thick boundary clay with anomalous enrichment in iridium, shocked quartz and microtektites, abundant soot-like carbon, and a negative excursion in bulk carbonate and kerogene $\delta^{13}\text{C}$. The Danian succession consists of a 0.15 m dark green-grey, bedded, clay-rich, porcellanite overlain by 9.2 m light green-grey,

bedded, clay-poor, porcellanite; 18.5 m light green-grey, bedded, clay-poor siliceous limestone; 7 m pink, bedded limestone and 8 m yellow-brown, quartz-rich limestone with rare chert nodules (Hollis et al., 2003).

Fossil content

The site contains common planktonic foraminifers and radiolarians throughout, whereas benthic foraminifers and diatoms are common in some intervals. Dinoflagellate cysts and other palynomorphs are present in the uppermost Maastrichtian and lowest Danian. Most of the calcareous nannofossils are too poorly preserved for confident identification (Hollis et al., 2003). No macrofossils are recorded from Woodside Creek.

Significance of the site

The Woodside Creek site is one of the three classic locations for the discovery of the iridium anomaly (Alvarez et al., 1980) and is the stratotype for the radiolarian RK 9 and RP1–RP4 biozones (Hollis et al., 2003). The succession is tilted and the K/T boundary can therefore only be studied in a limited area.

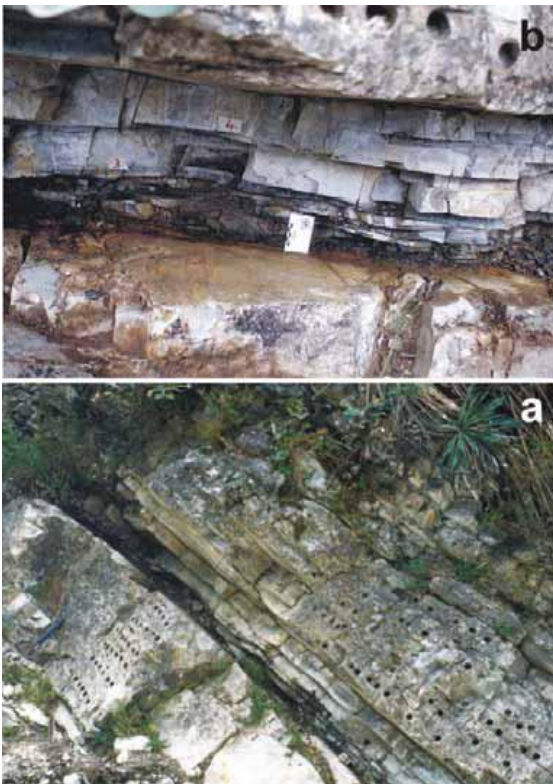


Figure 11: The K/T boundary at Woodside Creek. The boundary layer is located in the deep fissure (From Strong and Hollis, 2009: Photo a C. Hollis, Photo b B. Field).

4.10 Flaxbourne River, New Zealand – Marine section

Geographic description of the site

The Flaxbourne River site is located on the northern South Island of New Zealand within the Chancet Quarry. A guide is needed to locate the K/T boundary (Strong and Hollis, 2009).

Lithology and palaeoenvironment

The Maastrichtian succession consists of 13.2 m light green-grey limestone with thin marl partings overlain by 2–3 cm white marl, with an irregular upper contact. The K/T boundary is marked by a 1–3 cm thick layer which consists of a 3–5 mm thick basal red brown clay layer enriched in iridium, an 8–10 mm thick grey layer, and an uppermost 8–10 mm thick grey brown layer. The overlying Danian succession consists of 48 cm thick, dark grey, laminated, bedded, clay-rich porcellanite alternating with calcareous, siliceous claystone and 10.5 m yellow-grey, bedded, clay-poor porcellanite to siliceous limestone (Hollis et al., 2003).

Fossil content

The site contains common planktonic foraminifers and radiolarians throughout, whereas benthic foraminifers and diatoms are common in some intervals. Dinoflagellate cysts and other palynomorphs are not found at the Flaxbourne site and no macrofossils are recorded (Hollis et al., 2003)



Figure 12: The K/T boundary at Flaxbourne River, Chancet Quarry (From Strong and Hollis, 2009: Photo C. Hollis).

4.11 Mimbral, Mexico – Marine section near the impact area

Geographic description of the site

The Mimbral site is located in northeastern Mexico on the southwestern flank of the isolated mountain range Sierra de Tamaulipas. It is located on the southern bank of the Mimbral creek approximately 10 km east of the main road from Ciudad Victoria to Tampico (Keller et al., 1994).

The site is 152 m long and of variable height, ranging from 1 m to 36 m. It is reached by a rough, unpaved, and often poorly graded dirt road (Keller et al., 1994).

Lithology and palaeoenvironment

The Maastrichtian succession consists of 30 m of rhythmically bedded marls and limestones and occasional thin bentonite layers overlain by clastic deposit of variable thickness from 0.2–3 m, apparently representing channel-fill. The channel fill sediments consist of a basal unit characterised by spherules and relict impact glass overlain by a unit of laminated sandstone with mud clasts and plant debris at its base followed by series of cross-laminated sandstone, siltstone, and mudstone layers (Hough et al., 1997). The cross-laminated beds are overlain by a 4 cm thick silt layer, enriched in iridium. The iridium enriched layer is overlain by 7 cm of micritic limestone which again is overlain by up to 2.5 m of greyish shale (Smit et al., 1996). The channel fill sediments are designated as the K/T boundary sandstone and has been interpreted as deposited by large tsunami waves, caused by the Chicxulub impact (Smit et al., 1996). Although the impact itself did not occur in the deep ocean basin a large part of the ejecta curtain, presumably thousands of cubic kilometres, fell in the Gulf of Mexico, and slope failures along the Campeche escarpment may additionally have triggered tsunamis (Smit, 1999).

Fossil content

The site contains foraminifers and abundant trace fossils. Furthermore, the middle unit of the channel contains rare siliceous sponges and is rich in plant debris and pieces of wood.

Significance of the site

The Mimbral site is located very close to the Chicxulub impact area and the succession shows the result of the impact in deep water, not as the classical impact ejecta layer but as a presumed tsunami layer caused by the impact.

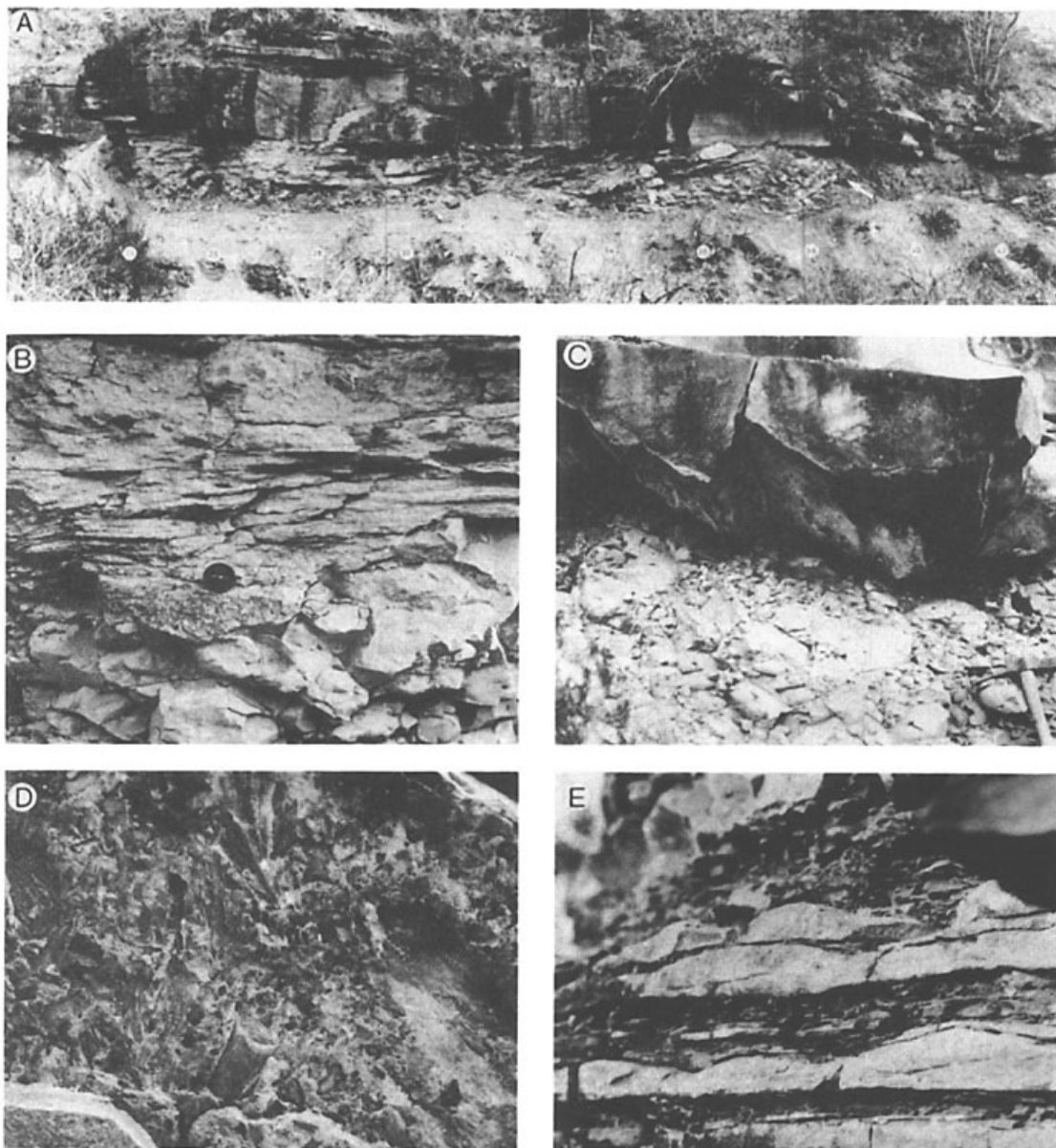


Figure 13: The K/T boundary at Mimbral. A) View of outcrop; circled numbers indicate 2 m horizontal intervals. B) Deep scour with spherules. C) Groove casts at the base of lowest laminated bed. D) Fossil plant material in lowest laminated bed. E) Rippled sandstone beds separated by clay layers (From Smit et al., 1992).

4.12 Beloc, Haiti – Marine section near the impact area

Geographic description of the site

The Beloc site is located in the southern part of the Haitian peninsula along the road from Port au Prince to Beloc and Jacmel (Leroux et al., 1995; Stinnesbeck et al., 1999). A complete K/T interval is preserved in a graben about 1 km north of Beloc on a steep slope and 30–40 m below the road. All other road cut sites are

intensely faulted, folded and sheared and in particular the K/T boundary clay is generally sheared and highly condensed (Stinnesbeck et al., 1999).

Lithology and palaeoenvironment

The Beloc site consists of more than 100 m of Upper Cretaceous and 30 m of horizontal Danian which are exposed along the hillslope. The Maastrichtian succession consists of pelagic marly limestone with an undulating erosional upper surface (Stinnesbeck et al., 1999). The K/T boundary is marked by a 30 cm thick layer of spherules possibly representing impact ejecta (Leroux et al., 1995). The K/T boundary layer is 10–30 cm thick in road outcrops and reaches a maximum thickness of 70 cm along the slope. The upper 5–15 cm are characterised by the presence of abundant black glass spherules, abundant spherule debris and rounded limestone clasts. The K/T boundary layer is overlain by 6 cm of Cretaceous bioclastic limestone and on top of this is a 2 cm thick grey-green shale layer with a thin, rust-coloured layer containing maximum concentrations of iridium, Ni-rich spinels and shocked minerals (Leroux et al., 1995; Stinnesbeck et al., 1999). The iridium-rich layer is overlain by a 50 cm thick limestone layer, which is overlain by a 0.5 cm thick and rust-coloured clay layer characterised by a palladium enrichment and low iridium values. The clay is overlain by a 1 cm thick volcanic tuff layer and a 10 cm thick volcanic-rich marl layer. The Danian succession consists of marly limestone (Stinnesbeck et al., 1999).

Fossil content

The site contains a rich and varied microbiota of foraminifers, radiolarians, calcispheres, sponge spicules, and ostracods (Stinnesbeck et al., 1999).

Significance of the site

The Beloc site is famous for the content of vesicular glass cores inside spherule droplets and 1–2 cm-sized blebs with rims of smectite (Smit, 1999). The site probably suffered from a major extraterrestrial impact at or before the K/T boundary as suggested by the spherule-rich layer, possibly a second impact event suggested by the iridium anomaly, and a major volcanic event suggested by the palladium-dominated anomaly (Stinnesbeck et al., 1999).

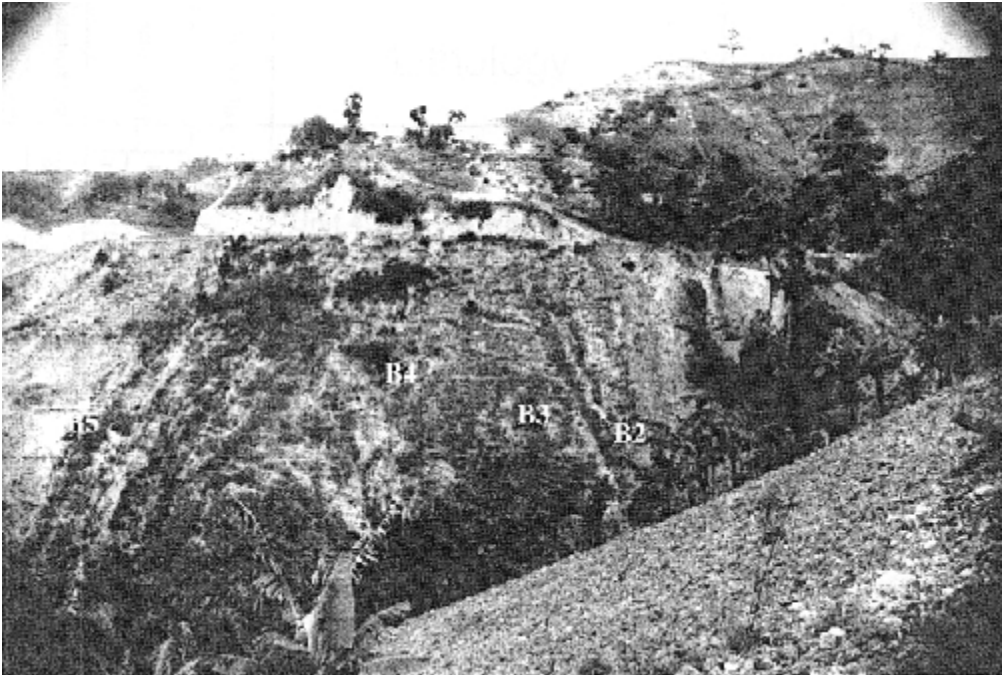


Figure 14: The K/T boundary at Beloc. B2 – B5 represents K/T interval sections (From Stinnesbeck et al., 1999)

4.13 Brazos River, USA – Marine section

Geographic description of the site

The Brazos River site is exposed in the low banks and on the floor of the Brazos River, near the town of Rosebud in Falls County, central Texas. The site is exposed for a few hundred metres to the north and 1–2 km to the south of the roadbridge where Route 413 crosses the Brazos River (Gale, 2006).

Lithology and palaeoenvironment

The Brazos River site consists of the Maastrichtian Corsicana Formation below the K/T boundary layer and the Kincaid Formation above it. At one place the site comprises about 1 m of Cretaceous clay with dark grey clay clasts which show evidence of physical disturbance quite unlike the underlying undisturbed, massive, grey claystone. The disturbed clay is overlain by a sandstone complex known as the “event deposit” interpreted by some as a tsunami deposit. The event deposit consists of 10 cm laminated skeletal sandstone with phosphate and glauconite grains, impact spherules, and shells in horizontal, current-stable orientations. This is overlain by a 10 cm thick calcareous, organic-rich, silty, fine-grained quartz sandstone with well developed hummocky cross-stratification which is capped by a 1–2 cm thick sandy claystone with minor iridium concentrations. The event deposit is overlain by a 5 cm thick silty limestone and a 10 cm thick massive grey

claystone both with minor iridium concentrations. The grey claystone contains no macrofossils except for a few contained in burrow fills descending from the overlying unit which consists of a 3.5 cm thick claystone with sandy laminae. This unit is overlain by a 2.5 m thick silty claystone with sparse fossils and maximum values of iridium. The event deposit is highly variably laterally and in thickness throughout the Brazos area (Hansen et al., 1987; Keller et al., 2007).

Fossil content

The site contains a rich and varied microbiota of foraminifers, calcareous nannofossils, ostracods, and palynomorphs. Furthermore, it is one of the few K/T boundary sites where the macrofossils are well preserved and includes ammonites, bivalves, gastropods, scaphopods, solitary corals, and trace fossils (Hansen et al., 1987; Gale, 2006; Keller et al., 2007).

Significance of the site

The Brazos River site is famous for the macrofossil content and for the controversy about the placement of the K/T boundary. The palaeontologically defined K/T boundary, including the mass-extinction of foraminifers, first appearance of Danian species, iridium anomaly, and the $\delta^{13}\text{O}$ shift occurs significantly above the event deposit which contain impact spherules near the base and small iridium concentration within the laminated sandstone (Keller et al., 2007).



Figure 15: The (K/T boundary at Brazos River, Falls County, Texas (pick and shovel for scale). The pick rests on a rippled sandstone bed immediately below the paleontological K-T boundary at this locality. The overlying dark, calcareous mudstone containing the iridium anomaly (Photo Alan Hildebrand).

4.14 Raton Basin, USA – Terrestrial section

Geographic description of the site

The Raton Basin site is located at the top of a saddle about 1.5 km west of Raton on Southwell Mountain Road, the old Raton Pass Road, in New Mexico, USA. The roadcut exposes the first outcrop discovery of the iridium anomaly in the Raton basin. Several K/T boundary sites are preserved in the east-central part of the basin.

Lithology and palaeoenvironment

The K/T boundary is preserved in a succession of coal-bearing, fluvial deposits in the lower part of the Upper Cretaceous – Danian Raton Formation, which is up to 640 m thick. The boundary occurs at the base of a 2.5 cm thick layer of rusty-weathering kaolinitic claystone, the boundary clay layer, in an interval of coal and carbonaceous shale. The boundary is defined by the disappearance of certain pollen taxa and the presence of shocked quartz grains and anomalies of iridium, chromium, and other elements (Gardner and Gilmour, 2002; Keller et al., 1995; Nichols, 2007; Pillmore et al., 1999).

Fossil content

The site contains palynoflora, leaf megafossils, and in many areas the boundary is associated with Maastrichtian dinosaurs below and Paleocene mammals above (Nichols, 2007).

Significance of the site

Palaeomagnetic studies have demonstrated that the K/T boundary in terrestrial rocks is within subchron C29r, as it is worldwide in marine rocks.

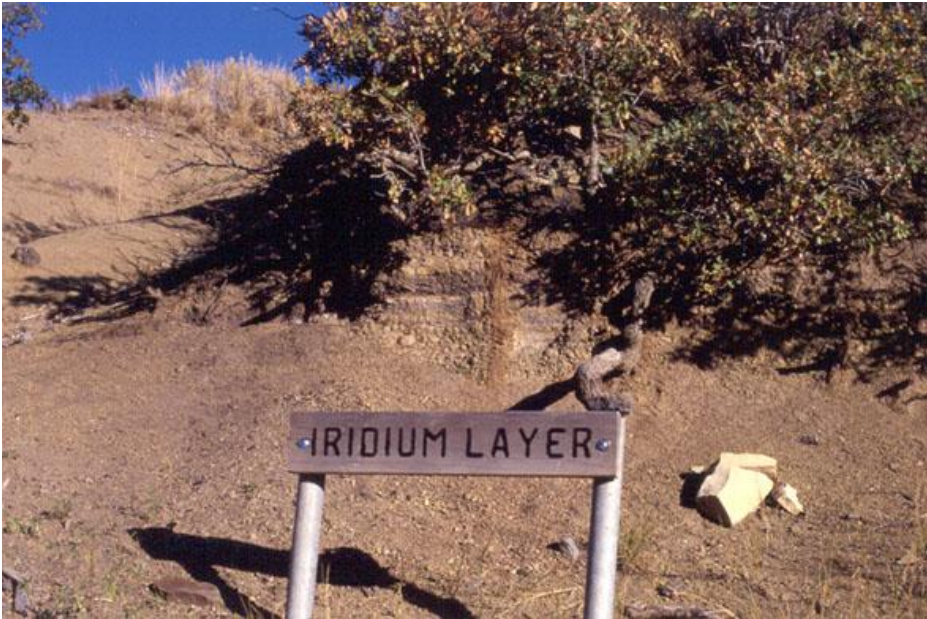


Figure 16: The K-T boundary exposed at the Raton Pass site. The boundary claystone layer is visible about midway between the top of the sign and the shrubs on the bank behind the sign (From <http://esp.cr.usgs.gov/info/kt/>).



Figure 17: Closer view of the Raton Pass site. The knife blade is at the boundary claystone layer (From <http://esp.cr.usgs.gov/info/kt/>).

4.15 Hell Creek, USA – Terrestrial section

Geographic description of the site

The Hell Creek Formation extends nearly 700 km from east to west and is exposed in Montana, North Dakota and South Dakota with the type area located on the south bank of the Fort Peck Reservoir in Glendive, Montana. The thickness of the formation varies from a maximum of 170 m in Garfield County, Montana to a minimum of 41 m in McCone County, Montana (Johnson et al., 2002). The K/T boundary layer is surprisingly thin and unremarkable and can be difficult to recognise it in the field (Bigelow, 2009).

Lithology and palaeoenvironment

The K/T boundary site of Hell Creek is contained within the Hell Creek Formation. The 3 cm thick K/T boundary clay is enriched in iridium and shocked quartz grains and is preserved at the base of a 145 cm thick lignite layer. The lignite contains several ash layers and contains typical Cretaceous pollen taxa at its base. Compared to the lower parts of the Hell Creek Formation the 10 cm of lignite that overlie the boundary clay contain an unusually large amount of fossil fern spores. The Hell Creek Formation comprises; cross-stratified and ripple-laminated sandstone, siltstone, carbonaceous mudstone, and lignite. Siltstone dominates the Upper Hell Creek Fm whereas the iridium-bearing K/T boundary clay is preserved only in the lignite. The site also contains volcanic ash layers which provide radiometric control on the timing and duration of the carbon isotope excursion (Arens and Jahren, 2000; Bigelow, 2009)

Fossil content

The site contains pollen and wood fragments from a diverse flora and root traces are common. Furthermore, it contains all common taxa of Late Cretaceous dinosaurs and a diverse insect fauna.

Significance of the site

The Hell Creek site covers a huge area and is one of the few complete terrestrial K/T boundary sites. It contains all common taxa of Late Cretaceous dinosaurs which are found at all known localities (Johnson et al., 2002).



Figure 18: The Hell Creek Formation is well exposed in the badlands in the vicinity of Ft. Peck Reservoir (http://en.wikipedia.org/wiki/Hell_Creek_Formation).

4.16 Seymour Island, Antarctica – Marine section

Geographic description of the site

The Seymour Island site is located on the northeastern tip of the Antarctic Peninsula along the southwestern and central parts of the island (Brizuela et al. 2007).

Lithology and palaeoenvironment

The K/T boundary site of Seymour Island is contained within the marine Lopéz de Bertodano Formation which reaches a thickness of about 1,190 m. The formation consists of shallow marine muddy sandy siltstones, muddy sandstones and occasional glauconitic sandstones. The K/T boundary is found within a widespread glauconitic interval which crops out along strike for about 5.5 km (Elliot et al., 1994); Brizuela et al. 2007). The beds are bioturbated but lack other sedimentary structures (Elliot et al., 1994).

Fossil content

The site contains a rich and varied microbiota, including dinoflagellates, diatoms, silicoflagellates, pollen, and foraminifers bivalves, ammonites, gastropods, polychaetes, echinoderms, solitary corals, wood, plesiosaurs, and trace fossils (Macellari, 1986; (Kiessling and Claeys, 2001)

Significance of the site

The Seymour Island site is one of only few sites at high southern latitudes that provide important information on the K/T boundary event.



Figure 19: The K/T boundary at Seymour Island (Photo by Andrew George Netting from <http://www.travelblog.org/Photos/2441989.html#>).

4.17 Hokkaido, Japan – Marine section

Geographic description of the site

The K/T boundary is exposed in the bed of a shallow stream of the Mokawaruppu River about 4 km upstream of the Kawaruppu Township on the island Hokkaido in Japan.

Lithology and palaeoenvironment

The succession consists predominantly of a massive, dark grey siltstone with occasionally calcareous concretions. A distinct, 6–10 cm thick greyish black claystone is the only lithological break in the otherwise monotonous sedimentary succession and represents the K/T boundary.

Fossil content

The site contains a rich and varied foraminifer fauna.

5. Comparison and evaluation of the K/T boundary sites

The 17 described sites, which all meet the main criteria, are compared in details in order to evaluate their potential as a World Heritage Site. Seven specific criteria are identified and used for the comparative analysis. The first criterion belongs to category 1 of Falcon-Lang (2002, chapter 1 this document), criteria 2 and 3 belong to category 2 and criteria 4 – 7 to category 3:

Specific criterion 1: *The fossil diversity*

Specific criterion 2: *The appearance of the boundary layer*

Specific criterion 3: *The lateral extent of the boundary layer*

Specific criterion 4: *The degree of exposure and permanency of the site*

Specific criterion 5: *The accessibility of the site*

Specific criterion 6: *Degree of research on the site*

Specific criterion 7: *Probability of continued discoveries*

These criteria are chosen since the K/T boundary represents a stratigraphic event and not a palaeontological site. The species diversity, the fossil density, and their state of preservation is thus not as important as the location and accessibility of the site, and the appearance of the boundary layer.

5.1 Comparative analysis

The seven specific criteria are quantified by giving each K/T boundary site points for issues that make the site a better World Heritage Site. Criteria 3 and 5 are given fewer points than the other criteria as the lateral extent of the boundary layer and the accessibility of site are less important for a WHS.

5.1.1: Fossil diversity

In this criterion the diversity of the major biota groups present in each site is calculated. The site is given 1 point for each group present at the site except for the macrofaunal group. At some sites the presence of macrofauna is described but in such insignificant numbers that it is impossible to study the evolution and faunal turnover for this group. Sites with an insignificant presence of macrofauna are given 1 point, whereas sites with macrofauna present which can be used for research is given 2 points. The site with the greatest number of groups and thereby the highest number of points is ranked first.

Table 3: Fossil diversity.

Site	Microfauna	Microflora	Macrofauna	Macroflora	Trace fossils	Points
Seymour Island	Present	Present	Present	Present	Present	6
Stevns Klint	Present	Present	Present		Present	5
Hell Creek		Present	Present	Present	Present	5
Nye Kløv	Present	Present	Present		Present	5
Brazos River	Present	Present	Present		Present	5
El Kef	Present	Present	insignificant		Present	4
Agost	Present	Present	insignificant		Present	4
Caravaca	Present	Present	insignificant		Present	4
Ain Settara	Present	Present	Present			4
Raton Basin		Present	Present	Present		4
Mimbral	Present			Present	Present	3
Elles	Present	Present			Present	3
Woodside Creek	Present	Present				2
Flaxbourne River	Present	Present				2
Gubbio	Present	Present				2
Beloc	Present	Present				2
Hokkaido	Present					1

The fossil diversity tells the evolutionary story of the biota across the K/T boundary. The more groups present the more studies can be made on the timing of extinction, the degree of extinction, survivorship of some groups, recovery after extinction, and selective extinction. Sites with a high number of groups can thus tell a more complete story of the extinction event.

Even though the macrofauna is less abundant it is ecologically more diverse than microfaunas in both habits and feeding types and may reflect regional patterns of stress and extinction better than the more dispersed microbiotas (Hansen et al., 1987). All kinds of fossil are therefore included in this criterion.

The Seymour Island site ranks highest with all major groups present. The Stevns Klint site ranks secondly, together with three other sites, due to the absence of macroflora. All of the sites which scores five points include macrofauna which has been used for research of extinction patterns.

5.1.2: Appearance of the boundary layer

This criterion evaluates the visibility of the boundary layer. Sites are given two points if the boundary layer is easily recognised and zero point if a guide is required to find it. Sites with an easily recognised boundary layer are ranked first.

Table 4: Appearance of the boundary layer

Site	Cannot be found without guide	Not easily recognised	Easily recognised
Stevns Klint			6
Caravaca			6
Agost			6
Woodside Creek			6
Gubbio			6
Ain Settara			6
Elles		3	
Mimbral		3	
Beloc		3	
Brazos River		3	
Raton Basin		3	
Nye Kløv		3	
Seymour Island		3	
Hell Creek		3	
Hokkaido		3	
El Kef	0		
Flaxbourne River	0		

The boundary layer, and thereby the event layer should be easily recognised to tell the story of the K/T boundary event when visiting and looking at the site. The Stevns Klint site, together with five other sites, contains an easily recognised boundary layer. At two sites, El Kef and Flaxbourne River, the boundary cannot be found without a guide

5.1.3: Lateral extent of the boundary layer

This criterion calculate the lateral extent of the boundary layer. The longer the boundary layer extends horizontally the more points. Sites with the longest horizontal extend are ranked first.

Table 5: Lateral extent of the boundary layer

Site	Less than a few metres	Few metres – 100 m	100 m – 1 km	More than 1 km
Stevns Klint				3
Hell Creek				3
Seymour Island				3
Brazos River				3
El Kef			2	
Elles			2	
Mimbral			2	
Beloc			2	
Ain Settara			2	
Caravaca		1		
Woodside Creek		1		
Flaxbourne River		1		
Raton Basin		1		

Nye Kløv		1		
Agost	0			
Gubbio	0			
Hokkaido	0			

The longer the boundary layer extends the more study material, such as fossils and impact material is accessible for research and the better is the opportunity for permanency of the site. The Stevns Klint site, together with Hell Creek, ranks highest with a lateral extent of more than 10 km. Eleven sites have a lateral extent of less than 1 km.

5.1.4: The degree of exposure and permanency of the site

The 17 sites are located in four different settings each representing different degrees of erosion and permanency. The setting which is ranked the lowest is quarries since the erosion degree is low and many quarries are filled with tailings and refuse after quarrying have ended so the degree of permanency is low. Roadcuts, valleys, and creeks normally are overgrown by vegetation and the erosion rate is low so both the degree of exposure and permanency is relatively low. Along streams, rivers, and channels erosion is continuous and thereby keep the site clean, but these waters may stop to flow which makes the degree of exposure relative high but the permanency relative low. Coastal cliffs are subject to natural continuous erosion which will keep a high exposure of the sites and the permanency high, since there is no risk of oversampling or overgrowth. Sites with highest degree of exposure and permanency are ranked first.

Table 6: The degree of exposure and permanency of the site

Site	Quarries	Road cuts, valleys and creeks	Along streams, rivers, and channels	Coastal cliffs
Stevns Klint				5
Seymour Island				5
Brazos River			3	
Mimbral			3	
Hokkaido			3	
Ain Settara			3	
Agost		2		
Gubbio		2		
Beloc		2		
Caravaca		2		
Woodside Creek		2		
Raton Basin		2		
Hell Creek		2		
El Kef		2		

Elles		2		
Flaxbourne River	1			
Nye Kløv	1			

The third category of Falcon-Lang (2000) bring together the World Heritage Site criteria that states that geological sites continuously subject to natural erosion such as sea-cliffs, are to be preferred over artificial excavations, because they are of greater permanency and are most likely to continuously yield new fossils in the future (Falcon-Lang, 2002). Only two sites are coastal cliffs and are ranked highest, Stevns Klint and Seymour Island.

5.1.5: Accessibility of the site

This criterion evaluates the accessibility of the site. Sites are given 1 point if access is easy by car. The criterion does not concern the access to the site after arriving by car or how far you have to drive from a town to get to the site. Sites with easy access are ranked first.

Table 7: Accessibility of the site

Site	Difficult access	Easy access
Stevns Klint		2
Agost		2
Gubbio		2
Beloc		2
Caravaca		2
Woodside Creek		2
Flaxbourne River		2
Brazos River		2
Raton Basin		2
Nye Kløv		2
Hell Creek		2
Ain Settara		2
El Kef	0	
Elles	0	
Mimbral	0	
Seymour Island	0	
Hokkaido	?	

The access of the site is important to get as many people as possible to visit the site. Unfortunately informations about the access to the Hokkaido are not available. Twelve of the seventeen sites have an easy access.

5.1.6: Degree of research on site

This criterion evaluates the scientific impact of the site in order to quantify the degree to which the site has been investigated. Data were collected from the online

databases Web of Science and GeoRef (Table 2). Numbers in the columns indicate numbers of publications found in either of the databases searching on locality name and K-T, K-P or C-P. Sites with highest scientific impact are ranked first.

Table 8: Degree of research on site

Site	10–20	21–40	41–60	61–100
El Kef				6
Stevns Klint			4	
Hell Creek			4	
Caravaca			4	
Raton Basin		2		
Brazos River		2		
Beloc		2		
Mimbral		2		
Agost		2		
Gubbio	0			
Hokkaido	0			
Nye Kløv	0			
Seymour Island	0			
Elles	0			
Flaxbourne River	0			
Ain Settara	0			
Woodside Creek	0			

The scientific impact may give an estimate on the amount of studies which have been carried out on the sites and to which degree the site has been investigated through time. This criterion is doubtful since for example the El Kef site, which is the stratotype for the K/T boundary, is cited in many publications without any research actually going on at this site. The El Kef site is therefore also the most cited site. Stevns Klint is ranked second together with two other sites.

5.1.7: Probability of continued discoveries

The last criterion attempts to assess the likelihood of continued significant discoveries in the future. This criterion is reached by adding the lateral extent of the boundary layer and the degree of erosion for each site. A large area with an exposed boundary layer together with continuous erosion may yield more fossils and not yet discovered features of the K/T boundary event compared to less exposed areas with less erosion. Sites with the highest potential of continued discoveries are ranked first.

Table 9: Probability of continued discoveries

Site	Lateral extent	Erosion	Total
Stevns Klint	3	5	8
Seymour Island	3	5	8
Brazos River	3	3	6
Hell Creek	3	2	5
Mimbral	2	3	5
Ain Settara	2	3	5
Beloc	2	2	4
El Kef	2	2	4
Elles	2	2	4
Hokkaido	0	3	3
Caravaca	1	2	3
Woodside Creek	1	2	3
Raton Basin	1	2	3
Nye Kløv	1	0	1
Flaxbourne River	1	0	1
Agost	0	2	2
Gubbio	0	2	2

This criterion is speculative but a requirement from the World Heritage Site criteria and is of importance for future investigation at the site. The Stevns Klint site is ranked highest due to its coastal location, which is preferable for permanency and erosion of the site, and due to its long lateral extent.

5.1.8: Cumulative table of the scores

Scores for each of the seven specific criteria as well as the total scores for each K/T boundary site are summarized. Numbers in columns correspond to those of tables: The fossil diversity, the appearance of the boundary layer, the horizontal extent of the boundary layer, the degree of exposure and permanency of the site, the accessibility of the site, degree of research on the site, probability of continued discoveries. The highest cumulative score is used as selection criterion for a K/T boundary site.

Table 10: Cumulative table showing that Stevns Klint has the highest cumulative score.

Site	Fossil diversity	Appearance of the boundary layer	Lateral extent of the boundary layer	Degree of exposure and permanency of the stie	Accessibility of the site	Degree of research on the site	Probability of continued discoveries	Total
Stevns Klint	5	6	3	5	2	4	8	33
Seymour Island	6	3	3	5	0	0	8	25
Hell Creek	5	3	3	2	2	4	5	24
Brazos River	5	3	3	3	2	2	6	24
Ain Settara	4	6	2	3	2	0	5	22
Caravaca	4	6	1	2	2	4	3	22
El Kef	4	0	2	2	0	6	4	18
Mimbral	3	3	2	3	0	2	5	18
Agost	4	6	0	2	2	2	2	18
Raton Basin	4	3	1	2	2	2	3	17
Beloc	2	3	2	2	2	2	4	17
Woodside Creek	2	6	1	2	2	0	3	16
Elles	3	3	2	2	0	0	4	14
Gubbio	2	6	0	2	2	0	2	14
Nye Kløv	5	3	1	1	2	0	1	13
Hokkaido*	1	3	0	3	?	0	3	10
Flaxbourne River	2	0	1	1	2	0	1	7

* Information about the Hokkaido section is scarce primarily because the literature about this section was not available. The Hokkaido section may therefore appear lower ranked than it should be.

6. Summary and conclusion

A comparative analysis of K/T (Cretaceous/Tertiary) boundaries around the world have been undertaken in order to evaluate their potential as a World Heritage Site (WHS). More than 500 K/T boundary sites are recorded worldwide but only 17 of these meet the three main criteria of completeness of the succession across the boundary, scientific documentation, and the presence of a boundary layer which are enriched in iridium and other elements considered to be mainly or partly of meteoritic origin.

Seven specific criteria are identified for the comparative analysis of the 17 sites meeting the main criteria. The specific criteria primarily concern appearance, extent, exposure, and accessibility of the sites. The specific criteria are selected in order to choose the site that presents this unique geological event in an easy way for all humanities as all the 17 compared K/T boundary sites illustrate the impact event, mass extinction and the faunal turnover across the boundary.

The Stevns Klint site ranks first in five of the seven specific criteria: the appearance of the boundary layer; the lateral extent of the boundary layer; the degree of exposure and permanency of the site; the accessibility of the site; probability of continued discoveries, and ranks second in two specific criteria: the fossil diversity and degree of research on the site, resulting in a total score on 33 points. Second best is Seymour Island with a score on 25 points. The Seymour Island site comprises the most detailed fossil record of the major biota groups with the macroflora preserved but the boundary layer is not easily recognised and it is difficult to get to the site since it is located on Antarctica. The Seymour Island site is therefore not a suitable WHS. Hell Creek and Brazos River both scored 24 points. In Hell Creek the boundary layer is exposed in a valley and may therefore be covered by vegetation and scree and get even more difficult to find or disappear in the future. The Brazos River boundary layer is exposed along a river and has a higher potential of continuous erosion but at both sites the boundary layer is not easily recognised. The stratotype locality El Kef ranks low in almost all specific criteria and ends with a total score on 18 points. El Kef would not be suited as a WHS since the boundary layer is difficult to find, the access to the site is difficult, and the site is endangered by oversampling and agricultural encroachment, and will probably not remain for future generations of humanity.

The classical Stevns Klint K/T boundary site has not only the highest score in the comparative analysis but stands out from all other sites with its beautiful

coastal position and the easily recognised K/T boundary layer, immediately beneath the topographic overhang that separates the lowerlying, soft Cretaceous chalk from the harder Tertiary limestone above. Stevns Klint is arguably the most famous, scenic and best exposed K/T boundary locality in the world. Together with the nearby Faxø quarry it constitutes the type locality of the Danian Stage and, furthermore, it is one of the discovery localities of the famous iridium anomaly, which formed the basis for the asteroid impact hypothesis of Alvarez et al. (1980) proposed to explain the mass extinction at the end of the Cretaceous. Stevns Klint is therefore a key locality in the ongoing debate about the K/T boundary and international researchers have flocked to Stevns Klint to sample the famous iridium-rich boundary layer and collect macro- and microfauna and nannoflora across the boundary.

The faunal assemblage is unique at the Stevns Klint site since it includes a diverse macro invertebrate fauna which expands the understanding of invertebrate recovery and evolution after the K/T mass extinction event. The invertebrate fauna is rarely found at other marine sites and has only been studied at Stevns Klint, Brazos River, Nye Kløv, and Seymour Island.

The geological story of the K/T boundary event, the lithology across the boundary, and many of macrofossils found at Stevns Klint are exhibited at Stevns Museum located at the village of Højerup. The museum is situated at the top of a stairway leading to the base of the coastal cliff at one of the best places to observe the K/T boundary layer. The easy access to the cliff and the story told by the museum makes it possible for tourists to go and study one of the major events in Earth's history, including the evolution of life across the boundary. Besides the numerous tourists and researchers visiting the Stevns Klint site every year it is also visited by student excursions and school classes. The Stevns Klint site is easily reached only about one hour drive from the Copenhagen airport and access to the coastal cliff is possible from several places along the main road 261 running from Strøby Egede to Rødvig.

The Stevns Klint site will remain for future generations of humanity due to the coastal cliff nature of the locality with ongoing erosion which maintain the quality of the site, exposes new fossils, and ensuring that the site is accessible for research. The site is not endangered by oversampling or by agricultural encroachment due to its coastal location.

This comparative analysis illustrates that Stevns Klint K/T boundary site in Denmark is the site most representative as a World Heritage Site. The Stevns Klint K/T boundary site stands out from all other sites in terms of exposure,

permanency, and very easy accessibility and it has the longest, continuous boundary clay layer which is easily recognised due to the lithology and the overhanging character of the cliff face. The Stevns Klint K/T boundary site provide is a superb record of geological features which represent an important event in the past development of the planet with the interpreted extraterrestrial impact, the associated mass extinction and the recovery of the global fauna across the boundary. The nominated site thus presents a unique record of a geological significant time in the Earth's history that is exceptional and of outstanding universal value.

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The scenic coastal cliff Stevns Klint comprises the most spectacular global mass extinction event in the history of the Earth: The Cretaceous—Tertiary boundary. The mass extinction that occurred 65 million years ago is particularly spectacular due to its association with an asteroid impact and because it marks the extinction of more than half of all species, including land-living dinosaurs and large marine reptiles.

At Stevns Klint the thin, black boundary clay found in the up to 40 m high, white cliff clearly marks the abrupt fall in primary production and makes the exceptional boundary visible even to the inexperienced eye. Stevns Klint is an outstanding locality representing a major stage in Earth's history and the record of life: The mass extinction at the Cretaceous—Tertiary boundary and is nominated for inclusion for the World Heritage List.

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Comment on the area of the nominated Stevns Klint

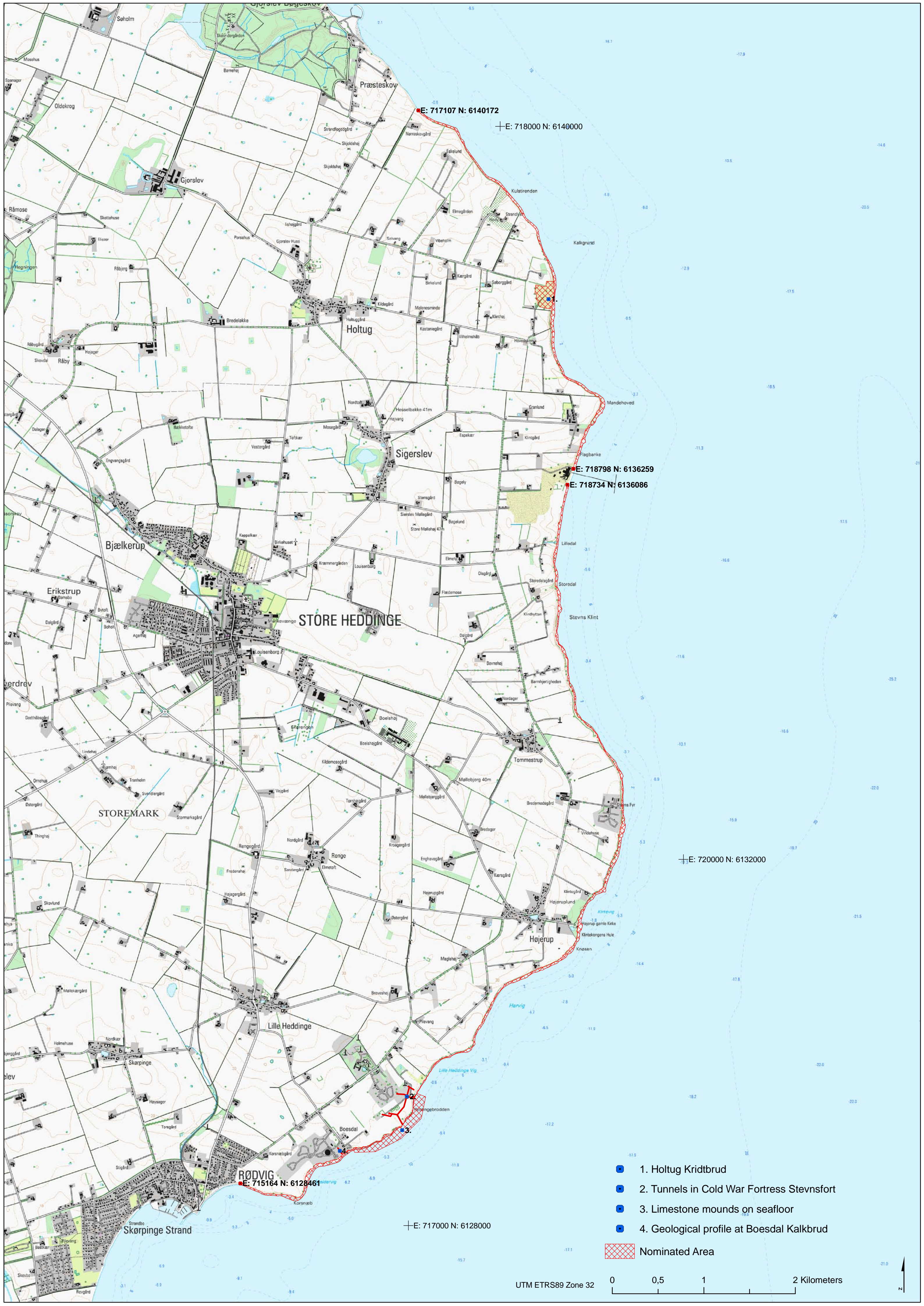
The nomination material of Stevns Klint for inclusion in the World Heritage List presents information on the area of the proposed site in section 1.f. (page 16 in the nomination material).

The area of the nominated property presented in this section is calculated on the basis of a mapping based on aerial photos.

A new mapping based on topographic maps shows a smaller area between the coastline and cliff break. The deviation of 10 ha between the previous mapping based on aerial photos and the new based on topographic maps is caused by the temporal variations in the area between coastline and cliff-break caused by the ongoing coastal processes causing the beach area to change due to changes in coastal currents, tide and storm waves combined with the ongoing coastal erosion of the cliff as described in section 1.e, 3.d, and 4.a of the nomination material. The deviation thus illustrates the inevitable uncertainty in the measurement.

	Nomination material section 1.f	Separate map	Deviation
	Based on aerial photos	Based on topographic maps	
Area	50 ha	40 ha	10 ha
Land	41 ha	31 ha	10 ha
Seafloor	9 ha	9 ha	No deviation
Buffer Zone	4136 ha	4136 ha	No deviation
Land	471 ha	471 ha	No deviation
Seafloor	3665 ha	3665 ha	No deviation
Total	4186	4176	10 ha

Table showing the deviation between the mapping of the nominated area based on aerial photos and based on topographic maps.



● E: 717107 N: 6140172

✚ E: 718000 N: 6140000

● E: 718798 N: 6136259

● E: 718734 N: 6136086

✚ E: 720000 N: 6132000

● E: 715164 N: 6128461

✚ E: 717000 N: 6128000

- 1. Holtug Kridtbrud
- 2. Tunnels in Cold War Fortress Stevnsfort
- 3. Limestone mounds on seafloor
- 4. Geological profile at Boesdal Kalkbrud
- ▨ Nominated Area

ID No.	Format	Date of photograph	Photographer	Copyright owner	Contact details of copyright owner	Non-exclusive cession of rights
Stevns Klint 1	jpg	27.07.2011	Peter Warnamoores	Photographer	GEUS	Yes
Stevns Klint 2	jpg	26.06.2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 3	jpg	26.06.2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 4	jpg	26.06.2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 5	jpg	26.06.2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 6	jpg	26.06.2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 7	jpg	26.06.2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 8	jpg	26.06.2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 9	jpg	26.06.2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 10	jpg	26.06.2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 11	jpg	26.06.2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 12	jpg	26.06.2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 13	jpg	02.07.2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 14	jpg	02.07.2011	Jacob Lautrup	Photographer	GEUS	Yes
Stevns Klint 15	jpg	01.05.2011	Sten Lennart Jakobsen	Photographer	Natural History Museum of Denmark	Yes
Stevns Klint 16	jpg	15.03.2011	Jan Schulz Adolfssen	Photographer	Natural History Museum of Denmark	

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Supplementary Information on the Nominated World Heritage site Stevns Klint



Content

1. Values and Justification for Inscription	1
2. Boundaries.....	9
3. Management	11
3.a. Governance, funding and staffing	11
3.b. Exclusion of extractive rights.....	17
3.c. Protection of geological values.....	29

Supplementary Information on the Nominated World Heritage site Stevns Klint

1. Values and Justification for Inscription

The panel will deliberate further on its view regarding whether it considers the nominated property meets natural criteria. It noted that the theme of the “record of life” is proposed (in addition to the themes of stratigraphy and meteoric impact as per Dingwall et al. 2005) in the justification for inscription, and therefore requests that the State Party address the questions and recommendations for fossil sites based on Wells 1996, notably the checklist of ten questions that provide the standard framework for evaluation of such sites. The list of questions is provided in annex to this letter.

In the nomination document Stevns Klint is proposed as the best locality on Earth to illustrate the major changes that have resulted from a meteorite impact, such as extinction. It is argued that Stevns Klint unrivalled fulfils the theme of meteoric impact as per Dingwall et al 2005. As the fossil record is of utmost importance for the quality of the site State Party is pleased to submit supplementary information on Stevns Klint as a fossil site including the IUCN Fossil Site Evaluation Checklist and the relevant Recommendations based on Wells 1996.

IUCN Fossil Site Evaluation Checklist

1. Does the site provide fossils which cover an extended period of geological time: i.e. how wide is the geological window?

Stevns Klint possesses an unrivalled fossil record of very high species diversity across the Cretaceous–Paleogene (K/T) boundary. The marine fossil fauna and the prominent presence of the impact layer, makes Stevns Klint the best locality worldwide to show the global effect of the impact by a meteorite and the associated mass extinction.

Stevns Klint represents a snapshot of dramatic changes in biodiversity and community structure across an extremely critical period in the evolution of life. A time where more than half of all species became extinct and the tree of life was severely pruned. The fossil-rich succession covers the story of the mass extinction that brought an end to the dinosaurs and the large marine reptiles, and of the succeeding recovery of the marine biota.

Stevns Klint represents a time span of about 1 million years, and shows a geological window of exceptional significance to the evolution of life.

2. Does the site provide specimens of a limited number of species or whole biotic assemblages: i.e. how rich is the species diversity.

The outstanding succession at Stevns Klint is world class as it provides a succession of three biotic assemblages starting with a high-diversity end-Cretaceous climax community, followed by post-impact disaster fauna, which is rapidly followed by a rich recovery fauna. These drastic changes in species diversity are fundamental in showing the effects of the severe mass extinction and the subsequent evolutionary changes leading the modern marine fauna.

The biota of the pre-extinction section is extremely rich in nanno-, micro-, meso- and macrofossils, including vertebrates and contains the most diverse end-Cretaceous marine ecosystem known, represented by about 500 invertebrate species and a very large number of micro- and nanofossil species. The disaster fauna following the impact horizon consists of minute gastropods and bivalves that survived the mass extinction together with a diverse shark fauna that apparently was little affected by the mass extinction.

A new diverse fauna rapidly evolved from the scattered survivors of the disaster fauna. The excellent fossil record of Stevns Klint illustrates how the niches previously inhabited by the extinct groups were rapidly filled in by new taxa. The ecological niche of the top-level predators, comprising the large marine reptile, the mosasaurs, was filled by surviving sharks, and the main predators of the Mesozoic Era, the ammonites were replaced by bony fishes, which diversified after the boundary.

The three succeeding biotic assemblages make Stevns Klint an outstanding locality to show the effect of a severe mass extinction on a climax ecosystem, including the mode and tempo of the subsequent recovery.

3. How unique is the site in yielding fossil specimens for that particular period of geological time: i.e. would this be the “type locality” for study or are there similar areas that are alternatives.

Stevns Klint is unique as it presents a highly diverse biota and a complete boundary section topping the most expanded end-Cretaceous section worldwide. Stevns Klint is therefore an obvious candidate as a stratigraphic boundary type locality. However, at the time when the stratigraphic type locality for the boundary was chosen Stevns Klint was erroneously supposed to be stratigraphically incomplete due to low-resolution sampling for microfossils. This has later been shown to be incorrect.

The stratigraphic type locality at El Kef was chosen on the bases of chemostratigraphic and micropalaeontological markers. The locality is rich in microfossils but compared to Stevns Klint it is very poor in macrofauna, including the large vertebrates. The boundary layer is normally scree-covered and not easy to identify without geochemical and micropalaeontological sample-derived data. Although El Kef fully qualifies as the stratigraphic type locality for the boundary, Stevns Klint undoubtedly is unrivalled for the study of faunal evolution across a mass extinction event.

4. Are there comparable sites elsewhere that contribute to the understanding of the total “story” of that point in time/space: i.e. is a single site nomination sufficient or should a serial nomination be considered?

The recognition by the American Alvarez group of a global mass extinction caused by the impact of a large meteorite at the K/T boundary led to a revolution in Earth Sciences and evolutionary biology. Until then the underlying paradigms was gradualism or uniformitarianism as it is normally termed in the Earth Sciences. This concept was marshaled by the British geologist Charles Lyell and his contemporary, Charles Darwin, and was developed to replace catastrophism which had its foundation in Biblical narrative. Today it is generally accepted that mass extinctions fundamentally change the evolutionary tree. Only the survivors can form the basis for subsequent evolution, and as the K/T event was the latest of the major mass extinction events the survivors form the basis for the subsequent gradual evolution towards the life we find on Earth today.

The mass extinction at the K/T boundary is the only one of the ‘Big Five’ mass extinctions which was caused by a meteorite impact and was geologically instantaneous. It resulted in complete extinction of the rulers of the Mesozoic world – the dinosaurs on land and the big reptiles and ammonites in the sea - and put an end to the most well-known of all prehistoric worlds. The outstanding boundary succession at Stevns Klint is unique globally as it not only shows the impact layer but contains the richest marine fauna known from the boundary strata at both low and high taxonomic levels.

Stevns Klint contains overwhelming faunal evidence for the mass extinction and the subsequent recovery associated with all the key points of the extraterrestrial impact present in the impact layer. The extremely high diversity pre-impact fauna makes Stevns Klint an outstanding world class locality to show the effects of the impact and associated mass extinction. In addition Stevns Klint was the first site proving the worldwide extent of the iridium anomaly at the K/T boundary and thereby formed the basis for the impact hypothesis.

Stevns Klint is thus the best locality world-wide for the story of the K/T boundary. If a serial nomination should be considered then the impact crater at Yucatán would be a candidate, if it were not for the fact that it is deeply buried and only known from boreholes and geophysical data.



Left: American scientist Walter Alvarez sampling the boundary clay at Stevns Klint 1978.

Right: Close up of impact layer.

5. Is the site the only main location where major scientific advances were (or are) being made that have made a substantial contribution to the understanding of life on Earth?

Although the effects of mass extinction have been studied at numerous locations worldwide Stevns Klint is iconic as a scientific site for the study of the K/T event. It was the discovery of an iridium anomaly in Stevns Klint by the American geologist Walter Alvarez in 1978 that demonstrated the global nature of the anomaly and led to the hypothesis of an extraterrestrial impact causing the mass extinction. This hypothesis published in the seminal paper in Science in 1980 led to greatly increased scientific interest reflected in more than 180 papers that have since followed based on studies of Stevns Klint material.

6. What are the prospects for ongoing discoveries at the site?

The prospects for ongoing discoveries at the site are considerable and new insights continue to appear as demonstrated by the continuing publication of papers in high-profile journals.

Ongoing palaeontological studies are focused on the nature, diversity and ecology of the immediate post-impact disaster fauna and new species are still being identified. The shark fauna is highly diverse and a large number of species apparently survived the extinction event. More detailed studies of the nanno- and microbiota supplemented with geochemical analyses of stable isotopes and trace elements are highly promising.

7. How international is the level of interest in the site?

Stevns Klint is of the highest international interest. Virtually all scientists working with the K/T boundary have visited Stevns Klint and the site has been studied by many international teams, resulting in more than 50 scientific papers per decade following the publication of the 1980 seminal paper by Alvarez et al. Stevns Klint has in addition gained great popular interest through numerous domestic and international magazines, popular books and TV features.

8. Are there other features of natural value (e.g. scenery, landform, and vegetation) associated with the site: i.e. does there exist within the adjacent area modern geological or biological processes that relate to the fossil resource?

Stevns Klint is arguably the most scenic K/T boundary site in the World – a picturesque white 15 km long sea cliff, the lower part consisting of soft white chalk and the upper part of harder protruding bryozoan limestone. This has given name to the cliff, 'Stevns' meaning 'stern', reflecting the topographic profile of the active sea-cliff.

The steep white cliff of chalk and limestone distinguishes the nominated Stevns Klint area from the surrounding landscape and forms a major influence on the wildlife on a regional scale. Stevns Klint has

been registered as an IBA (important bird area) by BirdLife International as the cliff is a major locality in the southward autumn bird migration route from Scandinavia.

9. What is the state of preservation of specimens yielded from the site?

The preservation of fossils with calcite shells is excellent and the soft nature of the chalk allows easy preparation of macrofossils, yielding superbly preserved specimens. Shells made of aragonite (e.g. all gastropods and ammonites) were dissolved in the chalk but early diagenetic hardening at some levels has ensured an excellent cast preservation showing even the finest details. Teeth of sharks, ray-finned fish, and mosasaurs are exceptionally well preserved.



Easy preparation of superbly preserved macrofossils.

Excellent cast preservation.

Exceptional preservation of shark and mosasaur teeth.

10. Do the fossils yielded provide an understanding of the conservation status of contemporary taxa and/or communities: i.e. how relevant is the site in documenting the consequences to modern biota of gradual change through time.

The site is of outstanding importance for the study of the nature of catastrophic mass extinctions and the tempo and mode of the subsequent recovery, and thus for understanding of mass extinction as a key evolutionary processes shaping the tree of life. As the mass extinction at the K/T boundary was the last of the 'Big Five' mass extinctions the survivors formed the basis for the evolution of modern life.

The Stevns Klint fossil site provides an excellent model for biotic changes through a dramatic but short-lived crisis. It provides a context for the understanding of the effects of global scale catastrophic events on the marine fauna with vast destruction on a very short time scale and severe long-term effects. This scenario is not just of geological interest but may act as an analogue for future catastrophic events caused by large extraterrestrial impact or major nuclear warfare leading to "nuclear winter".

Recommendations

Recommendation 1

Choose sites that contain well-preserved fossil accumulation of high species diversity which in combination best document the story of community and environmental change through time

Stevens Klint possesses an unrivalled, well-preserved accumulation of a high species diversity marine fauna across the K/T boundary. It is the best locality worldwide to document the full story of an impact by a large meteorite and the associated mass extinction, due to the extremely diverse marine fauna and the presence of the impact layer.

Stevens Klint illustrates the nature of the extinction, by showing which of the lower and higher taxa that became extinct and which survived, and by showing the tempo and mode of evolution of the succeeding post-impact fauna which evolved into the marine fauna of today. The latest community immediately preceding the extinction is extremely rich and diverse comprising a wide range of higher taxa, representing an end-Cretaceous climax community and offering the opportunity to study the effect on the biota in detail.

The preservation of the fauna is generally excellent with all details superbly preserved. Aragonite shells of the minute gastropods and bivalves of the post-impact disaster fauna were dissolved during burial but early diagenesis has ensured an excellent cast preservation, showing even the finest details.

Recommendation 2

The “events” to be represented in the history of life should, where possible, encompass the iconography of a tree of life not a ladder of progress.

The K/T extinction recorded at Stevens Klint encompasses a major evolutionary event which played a fundamental role in shaping the tree of life. The mass extinction caused rapid and comprehensive pruning of the tree with the termination of about half of all lineages on both species and family level. The extinction event affected most groups and caused total extinction of entire groups such as the non-avian dinosaurs.

Being the last of the “Big Five” mass extinctions and including the dramatic extinction of dinosaurs by extraterrestrial impact it holds a huge general appeal adding to its universal value. The extinction by extraterrestrial impact is a fate that could befall life at any time.

Recommendation 3

Choose fossil Lagerstätten and make provision for expanding the List of substitution sites/fossils to better tell any chapter of the story

Stevens Klint is the most important fossil site worldwide to illustrate the faunal development and evolutionary changes across the K/T boundary. It contains an extremely rich pre-extinction fauna,

succeeded by a post-extinction disaster fauna. This was followed by rapid evolution from small, peripherally isolated populations of a modern-type fauna which soon filled in most of the vacant niches.

The story of the mass-extinction is best told by the combination of the physical imprint of the impact and its effect on the biota. Stevns Klint is undoubtedly the most important site across the world to illustrate this combination with the exceptionally clear boundary layer combined with a most important fossil site, illustrating the faunal development and evolutionary changes across the K/T boundary.

Recommendation 4 (iii)

Present Phanerozoic history in terms of communities and/or stages in the evolution of major groups

Stevns Klint represents a key event in the history of life. It comprises a snapshot in time when the fossil record shows massive disappearances marking the onset of a new era.

Stevns Klint presents the history of a marine climax community, its collapse and subsequent recovery and diversification across the K/T boundary. Some major groups became extinct, others were strongly reduced in importance, and some were surprisingly not affected by the factors leading to the mass extinction. The large marine reptiles, such as mosasaurs became extinct, whereas the sharks seem almost unaffected and took over the role as top predators. The ammonites, the leading predators in the Mesozoic, also became extinct, and their role was overtaken by bony fishes.

Recommendation 6

Phanerozoic sites should be chosen so as to be representative in time and space of both community structure and selected phylogenetic lineages.

The biota at Stevns Klint is remarkable not only for the very high species diversities, but also for the large number of higher taxa. The community structures across the K/T boundary are thus very well illustrated by the succession and the faunas are highly representative for the marine biota before, during and after the K/T crisis.

Recommendation 7

Any fossil Lagerstätten chosen from the Phanerozoic should wherever possible be of high diversity and include significant invertebrate as well as vertebrate assemblages.

The biota of Stevns Klint shows an extremely high species diversity and density, and a wide range of invertebrate phyla is represented. The vertebrate assemblage comprises several mosasaur species, a diverse fauna of sharks, and ray-finned fishes.

Recommendation 8

A condition for granting World Heritage status should include provision for curation, study and display of any site/fossils

There is an eminent support for curation and study of Stevns Klint fossils, both locally at Østsjællanders Museum and nationally at the Geological Museum which is part of the Danish Natural History Museum, University of Copenhagen. There is a close cooperation concerning collection, preparation, curation, display and study of the fossils between these institutions, the Department of Geosciences and Natural Resource Management, University of Copenhagen, and the Geological Survey of Denmark and Greenland.

Fossils are displayed at the Danish Natural History Museum and locally in two exhibitions run by Østsjællanders Museum. A process to establish purpose-built new facilities for study and display on site is governed by Stevns Municipality and Østsjællanders Museum.

Supplementary Information on the Nominated World Heritage site Stevns Klint

2. Boundaries

“A succinct reasoning and justification for inclusion of anthropogenic exposures in contributing to the values of the nominated property is provided, in addition a record of the opportunities for visitor services and interpretation. For each of the three anthropogenic exposures it is indicated how these areas can be protected, for the long-term, from natural coastal erosion processes.”

The nominated area comprises three anthropogenic exposures, including the two abandoned quarries Holtug Kridtbrud and Boesdal Kalkbrud, and the military tunnels at Stevnsfort:

Holtug Kridtbrud (abandoned quarry)

Contribution to the geological values

The quarry provides an exposure of muddier, more chalk-like deposits characteristic of the Danian of the northern part of the cliff. This type of deposit is also found along the cliff and the exposure therefore contributes with only limited supplementary geological value.

Opportunities for visitor services and interpretation

The quarry provides high quality opportunities for interpretation especially for school services and for fossil collecting for amateur geologists.

Long term protection

With time (thousands of years) coastal erosion will slowly cause the quarry to disappear and a new coastal cliff will form. The coastal cliff will display the same lithology as is now found in the quarry. A coastal protection is therefore not recommended.

Boesdal Kalkbrud (abandoned quarry)

Contributing to the values

A fine example of an externally symmetrical but internally asymmetric bryozoan mound. The exposure is a fine and accessible example, but not unique to the cliff.

Providing opportunities for visitor services and interpretation

The exposure provides opportunities for demonstrating the complex 3D structure of bryozoan mounds.

Long term protection

Today the exposure is protected by natural coastal processes in the form of beach ridges in front of the cliff, inhibiting erosion. With the current pattern of coastal erosion, the main need for protection is limited to hindering lush vegetation in front of the exposure inside the quarry.

In the case of changes in coastal processes, natural erosion may start occurring. This will be identified by the monitoring programme and a detailed analysis of erosion will be initiated in order to produce a revised plan for protection.

If the natural erosion at that time is still as high as the calculated present average rate of 15 cm pr. year erosion of the exposure in the quarry is estimated to start after about 1-200 years. The main exposure inside the quarry will in this calculation start to erode about 300-350 years after erosion has started.

Stevnsfort (military tunnels)

Contributing to the values

The geological value of the exposure in the tunnels is very high as the tunnel walls provide a unique network of 3D exposures showing the internal structure of the complex bryozoan mounds as recently described by Bjerager & Surlyk (2007a,b).

Providing opportunities for visitor services and interpretation

The 3D exposures are very interesting to non-scientists, as the outline of the flint-bands makes the 3D geometry clear even to the unskilled visitor. The tunnels are visited by 30-40,000 guests every year, making it a high quality place for presenting geology to a wide range of visitors.

Long term protection

The cliff at Stevnsfort is composed entirely of bryozoan limestone and erosion is restricted to the lower few metres. To protect the tunnels without harming the bryozoan mounds exposed on the sea-floor and without significantly changing the view of the cliff from the sea, it is suggested to protect the lower few metres of the cliff in the area of the tunnel openings. This is expected to provide sufficient protection for the coming more than a hundred years. This coastal protection may be camouflaged making it barely visible from the sea and not visible from land.

References

- Bjerager, M., & Surlyk, F. (2007a). *Benthic palaeoecology of Danian deep-shelf bryozoan mounds in the Danish Basin. Palaeogeography, Palaeoclimatology, Palaeoecology*, 250(1-4), 184-215.
- Bjerager, M., & Surlyk, F. (2007b). *Danian Cool-Water Bryozoan Mounds at Stevns Klint, Denmark – A New Class of Non-Cemented Skeletal Mounds. Journal of Sedimentary Research*, 77(8), 634-660.

Supplementary Information on the Nominated World Heritage site Stevns Klint

3. Management

3.a. Governance, funding and staffing

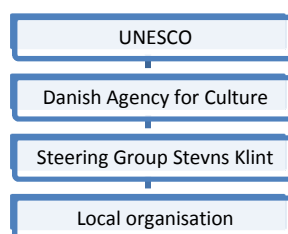
We would be grateful if the State Party would state clearly the governance (organizational structure and composition) currently in place for the management of the site, and that envisaged if the property is inscribed on the World Heritage list. Moreover it is further requested that the State Party provide an indication of the certainty and level of sustainable funding (and other resources) for the protection, promotion and presentation of the property – including the provision of staffing for management of the property.

Organizational structure and composition Stevns Klint

To ensure good governance of the protection, promotion and presentation of Stevns Klint and communication and coordination at all levels of major stakeholders a new organisation structure has been established based on the Stevns Klint Management Plan 2011. The organisation will be fully implemented by autumn 2014.

The organizational structure is established with the purpose of securing management of the site as a candidate for World Heritage in a form that may be continued, if Stevns Klint is inscribed on the World Heritage list. Maintaining and supporting the high degree of local community involvement is central to the organisation.

For the purpose of a clear organisation, that ensures the best conditions for the respective authorities and major stakeholders regarding World Heritage, a multiple route of communication is established as illustrated below.



Danish Agency for Culture

The Danish Agency for Culture has the overall responsibility in relation to UNESCO and handles all contact with the UNESCO secretariat in Paris.

The Danish Agency for Culture has the following role as regards the World Heritage Site:

- To work as a consulting party in relation to physical planning including changes and preparation of Stevns Municipality's District Plans, which may influence the World Heritage Site and its immediate surroundings;
- To prepare the framework for periodic reports for UNESCO;
- To evaluate the World Heritage Site Management Plan;
- To convey UNESCO initiatives to the World Heritage Site.

Steering Group Stevns Klint

The purpose of the Steering Group Stevns Klint is to ensure that the management and development of the Stevns Klint site is fulfilled in accordance with Danish legislation and UNESCO World Heritage guidelines.

The Steering Group Stevns Klint has recently been expanded in order to ensure representation of all relevant authorities responsible for the protection, promotion, and presentation of Stevns Klint and the main land owner:

- Danish Agency for Culture – State Party authority for Danish World Heritage IUCN/UNESCO
- Stevns Municipality – authority for The Act of Planning. Owner of Boesdal Kridtbrud and Stevnsfort
- Danish Nature Agency – authority for the Act on the Protection of Nature including the Beach Protection Line and Natura 2000 administration. Owner of Holtug Kridtbrud.
- Østsjælland Museum – responsible for presentation and research according to the Museum Act
- Gjorslev Manor (Gjorslev Gods) – primary land owner (95 % of the cliff face)

The Mayor of Stevns Municipality chairs the Steering Group.

Name	Number of seats
Danish Agency for Culture - special consultant (World Heritage Focal Point)	1
Stevns Municipality - Politicians (including the mayor) - Civil servants	3 2
Østsjælland Museum - Chair of museum board - Director	1 1
Danish Nature Agency - Civil servant	1
Gjorslev Manor (Gjorslev Gods) - Owner	1

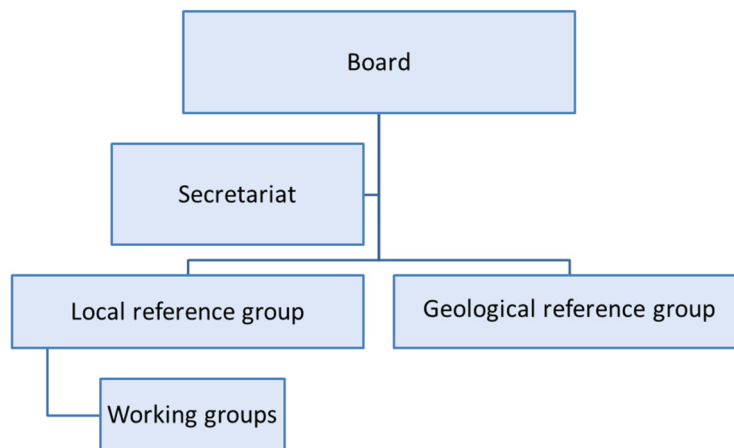
Table showing the representation in the Steering Group Stevns Klint.

Local organisation

The association “Development Group Stevns Klint” is recently founded and funded by Stevns Municipality in order to fulfil the need to create a local organisation that ensures the implementation of the goals of the Management Plan Stevns Klint 2011 including the coordination between a broad span of stakeholders. A main task for the local organisation is to ensure implementation of the monitoring programme and a sustainable development of the area.

The organisation is to ensure a competent and dialogue-based balance of all interests in relation to the vision set up for Stevns Klint. The objective is to create an organisation that can constitute the efficient and authoritative forum for development of measures and coordination of tasks in relation to Stevns Klint as a UNESCO World Heritage Site.

A main task is to ensure that the local community is involved in decisions of significance to their everyday life and to ensure communication with Danish geological community both for professionals and amateur geologists.



Board

The board of the Development Group Stevns Klint comprises members from Stevns Municipality, Østsjælland's Museum and Stevns Tourist Association. Stevns Municipality chairs the board.

To secure flow of information the chair of board is member of the Steering Group Stevns Klint and the director of the secretariat acts as secretary to the board as well as the Steering Group Stevns Klint.

Secretariat

The secretariat will be staffed by:

- Director (part time since October 2013)
- Site manager (by 15th of April 2014)
- Relevant project based employments

The task of the secretariat includes the fulfilment of the goals of the Management Plan Stevns Klint including the monitoring programme in accordance with the decisions of the Steering Group Stevns Klint. The secretariat secures the coordination and communication between the Steering Group Stevns Klint and other stakeholders and forms the support for the reference groups and working groups.

Local reference group

The local reference group will be established in April 2014 following the advice from the well-established contact group of local citizens that have been engaged in the process since the first local hearings as part of the World Heritage nomination process in 2010.

The local reference group is a dialogue forum for all subjects relevant to the management and development of Stevns Klint as World Heritage site. The broad composition of the group is to ensure that all major interests are represented. The work of the group is fully supported by the secretariat.

The local reference group may establish a number of working groups engaging in specific subjects concerning the management and development of the area.

Present members of the local reference group are shown in table below. More members may be included if relevant.

Members	Number of seats
Contact group (inhabitants of the buffer zone elected from four meetings held for the inhabitants of the buffer zone and Højerup village)	10
NGO (local associations and local sections of national organisations regarding nature protection, wildlife, cultural landscape, outdoor recreational activities including accessibility)	5
Local tourism organisation and trade council	2
Special interest (local sports clubs etc.)	1-3
Stevns Municipality	2

Table showing the representation in the local reference group.

Geological reference group

Today a close cooperation exists between the Danish geological community including the Department of Geosciences and Natural Resource Management, University of Copenhagen, the Geological Survey of Denmark and Greenland, the Geological Museum which is part of the Danish Natural History Museum, University of Copenhagen, and the local state approved Østsjælland Museum. The geological reference group will formalize this cooperation on management, research, presentation and collection.

The group is supported by the secretariat.

The group will be formally established in 2014 with participation of the above mentioned geological stakeholders.

Working groups

Working groups form an essential part of the organisation and will be established for specific purposes such as assistance with monitoring, improvement of visitor facilities, communication on fossil collection etc.

Working groups may be initiated by request from the dialogue-forum, the board or secretariat. The working groups are supported by the secretariat and may involve local community participation.

Level of sustainable funding for the protection, promotion and presentation

The level of permanent funding and staffing regarding the protection, promotion and presentation of Stevns Klint is high, as most of the tasks are already permanently funded within the relevant authorities responsible for the well protected Danish coastal areas of national geological interest and the organisations responsible for promotion and presentation.

As a supplement to the existing permanent funding, a five year programme has been initiated to ensure the implementation of new initiatives for management, presentation and promotion including the basis for the establishment of a new visitor centre. The programme is funded with 2 million Euros by Stevns Municipality. As part of the five year programme the need for permanent funding of Stevns Klint as a World Heritage Site will be evaluated and the relevant funding for the protection and management will be supplied from Stevns Municipality on a permanent basis.

As part of the programme a secretariat is established to ensure the coordination and communication between stakeholders and fulfilment of the tasks defined by the Management Plan Stevns Klint including the monitoring programme. The secretariat includes a skilled part time director employed by October 2013 and a highly qualified and experienced site manager employed by 15th of April 2014. The site manager has site manager experience from a World Heritage Site. The need for permanent staffing will be evaluated in the five year programme and permanent staffing funded by Stevns Municipality.

The construction of a new visitor centre depends on private funding as is the tradition for such projects in Denmark, whereas the running costs of a new centre are covered within the present funding to Østsjælland Museum.

Tasks performed by permanent staff

Tasks permanently funded and staffed are presented in textboxes below:

Management

Management of Stevns Klint as World Heritage is generally ensured by existing Danish legislation and therefore permanently funded by Stevns Municipality and the State (Danish Nature Agency).

This includes:

Planning (Stevns Municipality)

- Planning in coastal areas ensuring that they are kept free of buildings and constructions that are not dependent on coastal proximity.
- Municipal plans defining restrictions for land use including Stevns Klint as an area of National Geological Interest.
- Local planning – detailed planning for land use in local areas. In the buffer zone detailed local plans exist for Boesdal Kalkbrud, Stevnstort and Stevns Fyr. A local plan for Højerup will be finished in 2014.

Contact to citizens and stakeholders (Stevns Municipality)

- Inclusion of citizens according to the municipal policy for near-democracy and citizen participation. The aim of the policy is to secure an open and constructive dialogue between the municipality and its citizens, associations and companies.
- Inclusion of citizens in local planning process in Højerup.

- Communication with owners of the walking path along Stevns Klint including formal annual meetings.

Nature protection and coastal protection

- Beach protection line: main tool for protecting the areas 300 metres in land from any alteration from the present state and use. Funded by Danish Nature Agency.
- The protection of lakes, streams, grassland along Stevns Klint. Funded by Stevns Municipality.
- The protection of endangered special including reptiles and raptors. Funded by Stevns Municipality.
- Ensuring public access, so the beach is open to the public on foot, shorter stay and swimming.

Planning and management tasks regarding Stevns Klint has highest priority in Stevns Municipality. Staff needed for the task varies but is estimated to the equivalent of one full time position.

Running operational tasks

The following running operational tasks are already permanently funded:

- Nature care for habitats of protected species including grassland care (by Stevns Municipality and Danish Nature Agency supplemented by volunteer programmes).
- Nature care and daily supervision at all sites along the cliff owned by the State, Stevns Municipality, Østsjælland Museum and The Association Højeruplund: Holtug Kridtbrud, Mandehoved, Stevns Fyr, Højerup, Cold War Museum Stevnsfort and Boesdal. Staff funded by the owners.
- Maintenance of the walking trail along the cliff (funded by Stevns Municipality).
- Maintenance of visitor facilities along the cliff including road signs and information boards (funded by Stevns Municipality).

Nature care and care of visitor facilities employs about 5 permanent staff.

Collection and presentation

The state-approved Østsjælland Museum has obligations within the Museum Act to ensure collection, research and presentation of Stevns Klint. The museum receives permanent funding from the State and local municipalities and has an income from entrance fees.

The obligatory tasks include:

- Curating the valuable collection of Stevns Klint fossils.
- Presenting the collection to the public and visiting scientists.
- Research in the geology (and cultural history) of Stevns Klint.
- School services (pt. about 2.000 visitors pr. year but under expansion).
- Exhibitions (pt. a small exhibition open all year and a worn down exhibition at Højerup) including public guided tours.

Based on private funding an integrated presentation programme of Stevns Klint has been developed including new web site, a large digital app, flyers and information signs along the cliff. This presentation programme has been developed in cooperation with relevant stakeholders and has greatly improved the information level for the visitor. The running costs of the programme are permanently funded within Østsjælland Museum and Stevns Municipality. The museum holds 25 full time positions including two geologists (curation and science) and two full time positions for presentation of the Stevns Klint as a geological site (school service).

Promotion

Promotion of Stevns Klint as a natural visitor site is undertaken by Stevns Tourist Association through a contract with Stevns Municipality and supplemented by Østsjælland Museum. Present staffing for this task is estimated to two full time employees. Promotion of Stevns Municipality (where Stevns Klint is the main attraction) is permanently staffed by one full time position.

3.b. Exclusion of extractive rights

b) It is requested that the State Party provide documentation regarding the assurance for the exclusion of extractive rights (for limestone/chalk and or flint) from the proposed property. We note that it is a clear position of the World Heritage Committee that extraction industry is not compatible with World Heritage listing.

The legal framework regarding the protection of the proposed property concerning the extraction of raw materials is outlined in Appendix 4 to the nomination document, Stevns Klint Management Plan 2011, sec. 4.1.1, pp. 34, Raw material extraction. With reference to this document, State Party provides the following specification and documentation regarding assurance for the exclusion of extractive rights from the proposed property.

National policy regarding the protection of geological values

According to Danish law, no claimed rights for the extraction of raw materials can be granted or actively exercised without prior permission within a strict legislative framework. National legislation, regional planning as well as municipal management and control closely regulate permissions for the extraction of raw materials.

In the remarks to the management of the Planning Act, it is a clearly stated governmental objective to actively use the legislative framework, to secure that extraction of raw materials doesn't violate other rights and interests – particularly natural and geological interests. In 2013 this was repeated by the Minister for the Environment as a formal governmental policy regarding geological interests in the local planning: *“Valuable coastal profiles must be protected”* which states that the local municipalities, through their planning and administration must secure and protect areas of national geological interest against devaluation and destruction through i.e. extraction.¹

A number of international and national nature and geological interests apply to the nominated property: Stevns Klint is designated a European Geosite², organised by ProGeo on behalf of IUGS (International Union of Geological Societies). In 1984 Danish Forest and Nature Agency appointed Stevns Klint a National Site of Special Geological Interest³. The appointment of National Site of Special Geological Interest has been conducted to ensure that national geological values are heavily valued in the planning of the open land, and to ensure monitoring and the necessary care.⁴ Stevns Klint is appointed Coastal Landscape of National Interest by the Danish Forest and Nature Agency in order to maintain a rich and natural coastal landscape with special attention to the national geological values of the coasts.⁵

¹ *Oversigt over statslige interesser i kommuneplanlægningen 2013. (Overview of State Interests in the Municipal Planning 2013)*, Ministry of the Environment, sec. 8.2 Geology, p. 52.

² Registered as GeoSite GS 1-1 and GS 2-1, www.geosites.dk

³ Registered as Area of National Geological Interest NGI 128, www.naturstyrelsen.dk/Planlaegning/Planlaegning_i_det_aabne_land/GeologiskeInteresser/

⁴ *Apropos. Geologi i kommuneplanlægning for det åbne land (Geology in the municipal planning for the open land) 2009.* Ministry of the Environment.

⁵ Registered as Coastal Landscape of National Interest NK 28, www.naturstyrelsen.dk/Udgivelser/Aarstal/2004/Kyst.htm.

The national legislation and stated governmental policy towards the protection of very important geological sites like Stevns Klint emphasize the weight and special attention that geological interests must be given in the regional and municipal planning and management of existing and future extraction areas.

Regional and municipal planning and management of raw materials

According to § 3 of the Act on Raw Materials, the Regional Board and the local municipality must consider geological interests when appointing areas for raw material extraction and when granting permissions.⁶ This is further stipulated in § 11 of the Planning Act, according to which the local municipality must secure important geological values in all planning in accordance with the regional planning. This also applies to the appointment of extraction areas and granting of permissions for active extraction of raw materials.⁷

According to the raw material extraction plan for the period 2012-2023 from the Regional Board the area is reserved as future extraction interest area. One of the arguments for this designation is the number of claimed rights along the coast of the cliff. This plan will be revised every 4 year.

Further the nominated property is generally protected by the defined Beach Protection Zone according to §15 in the Danish Nature Protection Act, which provides a protection to alteration of the landscape within this zone that has to be considered in the regional and municipal planning and administration, including permission for construction of production facilities.⁸

These interests have to be considered by the municipality when managing existing extraction areas or granting permission for new areas of active extraction. The Regional raw material extraction plan is superior to the municipal plan. The clearly stated governmental policies regarding the protection of important geological values have recently been applied by Stevns Municipality in local planning. In a revision of the Stevns Municipal Plan 2013, it is stated that the extraction of raw materials can only take place if it doesn't endanger the specified geological interests, such as the nominated property.⁹

Appeal

Any decision regarding extraction permissions can be appealed if it doesn't conform to the respective laws or to the stated policy. The decisions can be appealed by a number of public authorities, special interest groups or by the owners according to the Raw Materials Act. Appeals are reviewed and processed by the Environment and Nature Appeal Board, which is an independent body appointed by the Parliament and the Supreme Court.¹⁰

In 2004 the Appeal Board considered a proposal for additional legal protection of Stevns Klint. The Board found that there was no need for further legal protection, stating that: *"Stevns Klint contains large landscape, geological and natural values. Extraction of raw materials in the area does not pose any specific danger to the proposed areas and especially the parts of the cliff in coastal proximity are sufficiently protected by the general legislation including the Beach Protection Line which will remain administered strictly. It is not considered necessary to legally protect Stevns Klint to prevent the extraction of raw*

⁶ *Råstofloven (Act on Raw Materials) §3*, Consolidated Act no. 657/2013, Ministry of the Environment.

⁷ *Planloven (Planning Act) §11,1,17*, Consolidated Act no. 587/2013, Ministry of Environment. From July 2014 all future raw materials planning and the granting of permissions for extraction will be transferred to the Regional Board.

⁸ *Naturbeskyttelsesloven (Act on Nature Protection) § 15*, Consolidated Act 870/2013, Ministry of the Environment.

⁹ Stevns Kommuneplan 13 (Municipal Plan 13), Stevns Municipality 2013

¹⁰ *Råstofloven (Act on Raw Materials) §26*, Consolidated Act no. 657/2013, Ministry of the Environment.

materials beyond the present permissions for extraction.” The Danish Nature and Forest Agency advised against further legal protection that might necessitate a general national compensation of the owners, stating that: *“Should an unexpected threat against the cliff arise through applications for permissions for extraction within the claimed rights along the coast, it would according to the Agency justify considerations about further legal protection of the specified area.”* In 2004 the protection of Stevns Klint was found sufficient and further applications for extraction as unlikely.¹¹

Two cases of decisions reviewed by the Appeal Board demonstrate the management practice of the laws and policies. In 1998 permission to extent an extraction of gravel beyond the limits of the extraction area specified in the regional planning was denied by the Appeal Board, as gravel can be found elsewhere, and as the extraction area would extent into an area of national geological interest.¹² Also in 1998, the Appeal Board partly ruled against a decision of the Regional Board regarding permission for extraction of clay in a valuable landscape. Permission was granted by the Appeal Board, but only as this type of clay could not be found elsewhere, at the same time denying the right to extent the extraction area into the Beach Protection Zone specified and protected by the Act of Nature Protection.¹³

Both cases document the intent and ability of the authorities and the Appeal Board to fulfil the intensions of the legislative framework in protecting geological and natural interests, thereby overruling regards to economic interests.

As all types of raw materials (chalk, limestone and flint) are very common and can be found within short distance from the nominated property in sufficient quantities, rarity or distance cannot be regarded as valid arguments for extraction at Stevns Klint. From its previous practice it could be assumed that the Appeal Board would dismiss any future applications or permissions for extraction with reference to the Act of Raw Materials. As there has only been few cases it is not possible to exclude that specific arguments in a new case would lead to a different conclusion. No new extraction permissions have been granted since the beginning of the 1950’ies, and there are no known applications for permission. The establishment of any new extraction site would be economically demanding and unlikely to be profitable.

Raw materials interests within the proposed property

No extraction of limestone, chalk and flint is exercised within the proposed property.

The private landowner Gjorslev Manor (Gjorslev Gods) has a historical claimed right to the extraction of raw material within the nominated property. This claim was made prior to 1972(it can historically be traced back to the 18th century), and according to a transitional paragraph in the Act on Raw Materials, this claim will expire in 2028 without any possibilities for further extension.¹⁴ The claim is reflected in mapping and planning of potential raw material resources in the region by the Regional Board according to the Act on Raw Materials.¹⁵

¹¹ Ruling by the Nature Appeal Board, Reg. nr. 08049.00. 27.08.2004.

http://blst.planvis.dk/download.php?kunde_id=39472000&filename=/08049.00.pdf

¹² Decision by the Environment and Nature Appeal Board, 4. juni 1998, j.nr. 97-41/650-0005

¹³ Decision by the Environment and Nature Appeal Board, 9. juni 1998, j.nr. 97-41/650-0007

¹⁴ All historical claimed rights are being phased out of practise through legislation. The date of expiration is given by law. *Råstofloven (Act on Raw Materials) §52a, sec. 2, Consolidated Act no. 657/2013, Ministry of the Environment.*

¹⁵ Region Zealand (2011): *Råstofplan for Region Sjælland 2012-23 (Raw Materials Plan for Region Zealand)*, Sorø in accordance to §5a in *Råstofloven (Act on Raw Materials)*, Consolidated Act no. 657/2013, Ministry of the Environment.

Gjorslev Manor has rented the rights to exercise these rights to a private company OMYA A/S. Gjorslev Manor has informed that they do not have plans to activate these rights but they have on the other hand declined to give up the claimed rights.

As shown above, the necessary permissions to activate the claimed right are highly unlikely to be granted before they expire in 2028.

It cannot be excluded that Gjorslev Manor or the private company OMYA A/S may want to activate the claimed rights. It is difficult to foresee what the final decision will be.

Raw materials interests in proximity to proposed property

Only one active area of extraction remains near the proposed property. According to the regional raw materials plan the extraction of chalk within a specified extraction area at Stevns Kridtbrud is permitted until 2033. Extraction can only take place within a clearly specified area located outside the nominated property. The Regional Board expresses a clear policy towards any future permission for the extraction of raw materials at Stevns Kridtbrud: *“Permission for the inclusion of new areas for the extraction of chalk can only be given within the existing extraction areas. No further permissions will be given for the extraction of chalk east of the road Hærvejen”*.¹⁶ As a consequence of this ruling, the extraction area cannot be extended beyond the presently specified limits within the regional raw material plan but only further away from the proposed property. A former extraction area within the proposed property at this site is now exhausted and is presently being re-established.

Appendixes for 3.b.

1. Abstract and translation of *Act on Raw Materials*, Consolidated Act no. 657 of May 27. 2013, The Ministry of the Environment.
2. Abstract and translation of *Act on Nature Protection*, Consolidated Act no. 951 of July 3. 2013, The Ministry of the Environment Naturbeskyttelsesloven
3. Abstract and translation from Stevns Municipal Plan/Stevns Kommuneplan 13, 2013
4. Extract and translation from *Outline of government interests in municipal planning 2013*, Danish Ministry for the Environment 2011.

Additional documentation for 3.b.

- A translation of The *Danish Planning Act* (Consolidated Act No. 813 of 21 June 2007) is available online at: <http://www.naturstyrelsen.dk/NR/ronlyres/07000CC6-C7F2-4DBE-B23A-018DF195E022/50763/planlovenpengelsk2007.pdf>
- An English language introduction to Spatial Planning in Denmark by the Danish Ministry for the Environment, 2007 can be found at: <http://www.sns.dk/udgivelser/2006/87-7279-728-2/pdf/87-7279-728-2.pdf>

¹⁶ Region Zealand (2011): *Råstofplan for Region Sjælland 2012-23 (Raw Materials Plan for Region Zealand)*, pp 11, guideline 5. Sorø

Question 3b – Appendix 1

Abstract and translation of *Act on Raw Materials*, Consolidated Act no. 657 of May 27. 2013, The Ministry of the Environment.

Chapter 1 Purpose

§ 1. The purpose of the law is to secure

- 1) that the exploitation of raw materials resources on land and at sea takes place in a sustainable way following a overall weighting of interests and an overall assessment of the considerations towards society as mentioned in § 3,
- 2) that extraction and processing is organized in a way, so that the re-established area can be utilized for other purposes,
- 3) a long term supply of raw materials,
- 4) that raw materials are used according to their quality and
- 5) that natural raw materials as far as possible are substituted by waste products.

§ 2. The law covers stones, gravel, sand, clay, chalk, limestone, turf, soil and similar raw material resources. The law does not cover any materials covered by the Act on the Danish Underground.

§ 3. By the administration of the law, emphasis should on one hand be placed on the quantity and quality of the raw material resources, the securing of the use of the raw material resources and business interests. On the other hand emphasis should be placed on the protection of the environment and water resources, the protection of archaeological and geological interests, nature protection and the preservation of landscape values and scientific interests, an appropriate urban development, infrastructure, agricultural and forestry interests, coastal protection, fishery interests, inconveniences for shipping and air traffic and changes to currents and sea floor.

...

The Danish Parliament has not passed and the Ministry of the Environment has not issued an official English translation of this Act. This translation is thereby nonauthorised and not legally binding.

Question 3b – Appendix 2

Abstract and translation of *Act on Nature Protection*, Consolidated Act no. 951 of July 3. 2013, The Ministry of the Environment Naturbeskyttelsesloven

Chapter 1 Purpose

§ 1. The law shall assist the protection of the nature and environment of the country, so the development of the society can take place on a sustainable basis in respect for living conditions of man and for the preservation of the life of animals and vegetation.

Subsection 2. The law is especially aimed at

- 1) the protection nature with it's population of wild animals and plants and their habitats and the landscape, cultural, natural and educational values,
- 2) the improvement, re-establish or provide areas of importance to wild animals and plants and the landscape and historical interests, and
- 3) to provide the possibility to the public of access to and stays in the nature and to promote the possibilities of out door experiences.

Subsection 3. By the management of the law, emphasis shall be placed on the value of an area to the public due to it's location.

...

Chapter 2 General provision for protection

Protection lines

Protection of the coastal areas

§ 15. It is prohibited to alter the state of beaches and other stretches of coast between the shore and the Beach Protection Line. It is prohibited to erect fences and to place caravans or the like. Parcelling out, land registration and transfer of ownership of land, whereby new boundaries are established shall be prohibited in such areas.

Subsection 2. The Beach Protection Line is defined by provision of the Minister for the Environment in accordance to the previously applicable provisions.

Subsection 3. The Beach Protection Line is registered in the Land Register and noted in Registration Protocol.

Subsection 4. The prohibitions in subsection 1 shall not apply to:

- 1) agricultural operations except for afforestation;
- 2) reforestation of forests and planting in existing gardens;
- 3) traditional fencing on agricultural and forestry properties;
- 4) existing military installations used for military purposes;
- 5) harbour installations and the land areas designated for harbour purposes in the a municipal plan;

- 6) Minor restorations of buildings, including replacements of windows, roofing etc. if the overall height of the building is not increased or is only increased to a minor extent;
- 7) Construction necessary for the operation of the property as agricultural or forestry estate or for the exercise of fishery exercised in immediate connection to existing buildings. The permission of the Minister for the Environment is needed, as the location and exterior design is concerned, and
- 8) Coastal stretches with protection of dunes according to §§ 8 and 9.

Subsection 5. The Minister for the Environment can give provisions, to the effect that subsection 1 shall not apply to specified types of structures that are also extended to territorial waters. The same applies to dikes and seawalls, jetties, breakwaters and other structures that require permission in accordance with the Protection of Coasts Act.

...

The Danish Parliament has not passed and the Ministry of the Environment has not issued an official English translation of this Act. This translation is thereby nonauthorised and not legally binding.

Question 3b – Appendix 3

Abstract and translation from Stevns Municipal Plan/Stevns Kommuneplan 13, 2013

Stevns Kommuneplan 13, Hæfte 2 Retningslinier. (Municipal planning directive for Stevns, vol. 2. Guidelines). Stevns Kommune 2013, sec. 5.8, 70 pp.

(Nonauthorized translation)

This municipal planning directive is prepared every four years in accordance to the Danish Planning Act and serve as policy and guidelines for all urban and rural development within the coming four years. The current plan was revised in 2013.

5.8 Areas of Geological Interest

In some places, the history of Earth can be read directly from the surface, in places where human activity has not erased the original landscape. Here you can find important stories of the past, for example, volcanic eruptions and earthquakes, or the various ice ages and how these events changed the landscape and human lives.

Goals

Stevns Municipality wants to:

- Ensure that geological interest are taken into account.
- Ensure that geological sites are preserved for research and mediation.
- Aid the accessibility of the public to valuable geological profiles.

Statement

Landscapes with varied geological formations are important to our experience and understanding of how the landscapes were formed. Many geological landscape formations are at the same time very recognizable and are of great value to the landscape.

There is an increasing pressure on the Areas of Geological Interest imposed by the development of towns, construction of larger roads, forestation, extraction of raw materials and coastal protection. Coastal protection i.e., should be avoided in areas, in which a National Area of Geological Interest consist of a coastal profile.

Like other landscapes of interest, the Areas of Geological Interest are vulnerable to the extraction of raw materials, construction of buildings, masts and windmills, forestation etc. Today, some types of building sites are so large that they have an impact on the landscape and can be dominating even when seen from a longer distance.

In the same way that Stevns Municipality strives to ensure the access to coastal areas, the access to geological values must be ensured.

The areas of interest are geological sites with fundamental value for the understanding of the geological development of Denmark. This means, that they are of special value to research and education.

National Areas of Interest

National Areas of Geological Interest are sites with a special value to the understanding of the geology of all

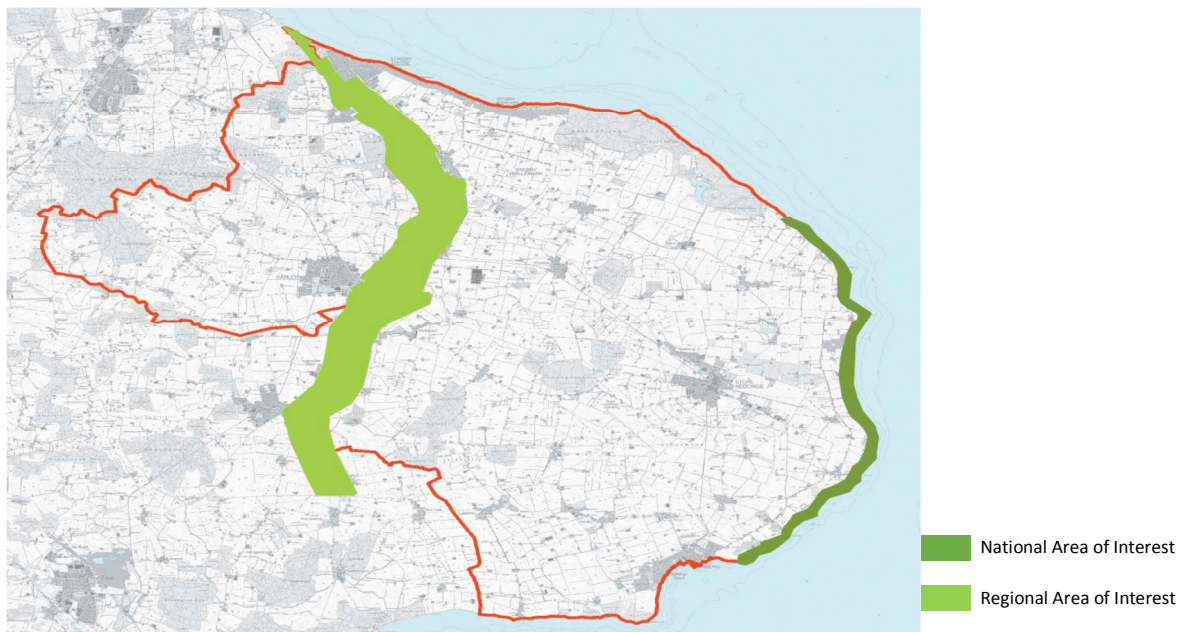
of Denmark, and which were included in the appointment by the government in 1984. Stevns Municipality has Stevns Klint as an Area of Geological Interest, and this is a site which also is of special value to international research and education.

With the Danish nomination of Stevns Klint as UNESCO World Heritage, the site will attract larger national and international attention. In connection with the UNESCO application process, a management plan was prepared containing framework and guidelines on for a sustainable management of Stevns Klint in accordance to the UNESCO World Heritage Convention.

A masterplan connecting the different sites and their special values was also prepared.

Guidelines for the planning in Areas of Geological Interest

- 5.8.1 Within the areas appointed as National Areas of Geological Interest or Regional Geological Interest shown in guideline map 5.8a, special attention must be paid to geology. Building and construction, technical plants, vegetation etc. should be established in another location and can only be carried out if no alternative is found. The extraction of raw materials can only take place, if geological interests are not destroyed.
- 5.8.2 Valuable landscapes and exposed geological profiles which particularly illustrate the landscaping should be secured and protected. This may include ridges, dales, hills, meadows, coastal areas and their surroundings.
- 5.8.3 By the reestablishment of former areas of extraction special attention must be given to geological interests. Geological profiles exposed by the extraction must be preserved if possible. As far as possible it should be secured, that the profiles are maintained after the extraction has ceased.
- 5.8.4 Areas of geological interest not applicable with forestation should be exempted from forestation.



Guideline map 5.8a Areas of Geological Interest

Question 3b – Appendix 4

Extract and translation from *Outline of government interests in municipal planning 2013*, Danish Ministry for the Environment 2011.

Preface

By Karen Ellemann, Minister of the Environment

When the municipalities know the Government's interests in advance, conflicts between government and municipal interests in planning can be prevented. Experience from the review of the municipal plans in 2009 shows that the former outline, along with early dialogue with the municipalities, resolved problems through negotiation to a large extent.

The outline of government interests in the municipal planning for 2013 is to make it easier for the municipalities to gain an overview of current national objectives and requirements. It is important for me that the coming review of the municipal plans in 2013 will also take place without great conflicts between government and municipal interests, and that this becomes a process based on dialogue. In this connection, the outline is a tool to be used in the dialogue. In a number of areas, the Government has launched initiatives, which the municipalities are to follow up on in their planning. This applies not least to initiatives such as:

- Green Growth
- Green Transport
- Room for more wind turbines
- Denmark in balance in a globalised world
- National Planning Report 2010

We need to meet the great challenges that climate change will create, which includes reducing Denmark's dependency on fossil fuels. This will require planning of biogas plants, wind turbines and areas for energy crops. It will also require a focus on maintaining a careful balance between protection and use of the open land as we create room for new initiatives, while at the same time we need to protect our ground water, nature, the landscapes and the biological diversity. I expect the municipalities to meet the challenges in the open country in the best possible way.

The Government's Water and Natura 2000 plans have been submitted to a preliminary hearing and have now been sent out for public hearing until April 2011. The final plans will be of great importance for municipal planning in the future. The Government directed its focus at the municipalities in the peripheral areas in 2010. The Government's lead initiative, 'Denmark in balance in a globalised world', is being followed up by a number of other initiatives. One of these initiatives will be to seek to alter the Planning Act to provide the municipalities in the 2 peripheral areas with more local opportunities for planning in the coastal zone. This is to support a continued balance between towns, villages and the open country, but it is to take place within the framework of the urban/land zone division, and we are to continue to respect nature protection areas and the beach protection line.

It is essential that urban development is considered along with the traffic structure. Some of the initiatives in the 'Agreement on a green transport policy' particularly support the general interests in the planning, just as some of the initiatives are particularly relevant to municipal planning. Municipal plans can serve as an investment assurance for property developers when they are to make decisions about investments in construction, facilities and business. As municipal plans include frameworks that outline what can be

decided in district plans and for the individual parts of the municipalities, they provide important information for businesses and developers. Secure frameworks set out in the planning provide developers with a better foundation for making decisions about investments that promote growth and development in the municipalities. In Denmark, our drinking water comes from uncontaminated ground water.

It is a political objective to continue to guarantee clean ground water for the supply of drinking water. Consequently, municipal planning must secure areas with vulnerable drinking water and catchment areas for ordinary waterworks when deciding where to carry out urban development.

Many municipalities currently use digital municipal plans, which can be found both on the municipality's own website and in the nationwide *PlansystemDK*, which makes planning data available to everybody on the Internet, supplying data for many purposes. I look forward to the results from the collaboration between Local Government Denmark and the Ministry for the Environment about data models, so that the municipal plans can be included in the future digital management and thereby create shared advantages for the public and private sectors.

Great decisions and challenges reach beyond the boundaries of the individual municipality. The individual municipality will therefore strengthen its own growth potential if the municipalities collaborate on developing growth and competitive edge in areas that cut across geographical municipal and regional boundaries. The same is the case when municipal planning interacts with regional development planning and the regional growth forums' business development strategies. Intermunicipal collaboration in the municipal planning may benefit both citizens and business communities. I consider the planning of town and country based on qualitatively good solutions as a joint task, in which the Government, the municipalities and the regions each has a number of pieces that can complete the puzzle if they are positioned correctly. 3

I have great confidence that the municipalities will be able to complete planning in a fully qualified way that will also involve a concrete balancing of local interests in relation to national interests. I am certain that a good overview of government interests as well as early dialogue will create the basis for a review of the municipal plans in 2013 so that it will run smoothly and have a positive outcome at both a local and a national level.

...

8.2 Geology

Government objectives

It is an objective that landscapes and coastal landscapes with different geological formations and special geological values are secured.

The Danish Nature Agency has collaborated with the Geological Survey of Denmark and Greenland (GEUS) to prepare a national map of valuable geological areas. It is an objective to secure the National Geological Areas of Interest and the 99 national interests in the coastal landscape.

In Denmark, a number of GeoSites have been selected, which are included in a network of particularly significant European geological areas of scientific importance. The majority of these form part of National Geological Areas of Interest.

8.2.1 Requirements to the municipal planning

The municipal plans must include guidelines for securing main geological preservation values. The Planning

Act, Section 11a (1), item 16.

Landscapes with particularly characteristic geological formations that illustrate Denmark's geological development and processes are of great importance to the experience and understanding of the Danish landscape's formation. The characteristic geological formations are also of great importance to research, teaching and the connection to the population's nature and landscape appreciation, and they must be secured via the municipalities' guidelines.

8.2.2 Valuable geological landscape traits, their mutual transitions and connections must be secured. Comments to Act L571, Section 11a (1), item 16.

8.2.3 Valuable geological coastal profiles must be preserved. Comments to Act L571, Section 11a (1), item 16. 4

The guidelines in the municipal plans for the national geological interests must ensure that the municipalities work to secure and protect the selected areas. The national geological areas of interest must not be allowed to deteriorate by being blurred or destroyed by digging, construction of buildings, technical facilities, afforestation or similar.

GeoSites are of international scientific importance, and in terms of protection they can therefore be considered on a par with national geological areas of interest.

In order to secure the geological interests that are traversed by a municipal boundary, it is important that the municipalities collaborate across administrative boundaries.

Further information

General information about geological interests:

www.naturstyrelsen.dk/Planlaegning/Planlaegning_i_det_aabne_land/GeologiskeInteresser/

99 national interests for coastal profiles: www.naturstyrelsen.dk/Udgivelser/Aarstal/2004/Kyst.htm

GeoSites: www.geosites.dk/

Also see: Apropos no. 3: www.naturstyrelsen.dk/Planlaegning/Det_danske_plansystem/Kommuneplan/ApropoK

3.c. Protection of geological values

c) It is requested that the State Party provide further explanation of the protection of the proposed geological values, as it specifically relates to collecting paleontological materials, and other rock material. This should provide both details of the legal protection, as well as the means of its enforcement.

Legal protection and means of enforcement

The removal of any material from Danish coasts is regulated through the Danish Act of Nature Preservation and the Danish Act of Raw Materials Extraction. Removal that requires the use of equipment is not permitted.

The cliff face of Stevns Klint is private property and the private owner, Gjorslev Manor, has the rights of sampling from the cliff face. Gjorslev Manor, Stevns Municipality and Østsjælland's Museum have agreed on a set of guidelines that regulates collection of geological material along the coast and at the abandoned quarry Boesdal. The guidelines are submitted as an appendix to this answer (Appendix 1).

Accordingly any removal of material from any part of the cliff beyond these guidelines may and will be regarded as theft of private property and may be subject to legal prosecution in a court of law. Any deliberate damage beyond the guidelines done to the cliff surface with or without tools will be regarded as damage to private property and may be subject to legal prosecution in a court of law.

In general no digging, hammering or drilling or any other ways of taking samples from the cliff surface with the use of tools are permitted.

Sampling of fossils and rock material from the beach is permitted as the relatively rapid coastal erosion would rapidly destroy the fossils, making collection from fallen material essential to the preservation of important fossils that might otherwise be lost. The amount of collected material may not exceed that which can be removed without the use of equipment.

Collecting fossils or other geological materials in the cliff face for scientific purposes may be permitted. According to the agreed guidelines permission will be granted by Østsjælland's Museum.

Unique fossils are protected by Danish law in the Museum Act. When fossils are considered to be of exceptional scientific or exhibition value they are declared *Danekræ* (fossil troves) and thereby belong to the Danish State. Findings expected to be *Danekræ* must be reported or submitted to the Natural History Museum of Denmark or to the state-approved Østsjælland's Museum, which is the geological museum authority in the field. If the object is declared *Danekræ* a compensatory award will be given to the collector.

Three sections of Stevns Klint are considered to be especially vulnerable because of high visitor numbers and supplementary restriction applies for these areas as any collection of material with or without tools from the cliff face is prohibited. One of these sections is the section under the fallen church (at Højerup). This section is protected from natural erosion and here the use of tools on fallen blocks is prohibited.

Monitoring

A systematic monitoring programme is set out for the protection of the geological values with emphasis on overgrowth, vandalism and on the collection of fossils and rock samples.

In 2013 the condition of the most visited exposures were documented photographically. Twice a year a systematic recording of the state of the most visited exposures is performed. The systematic recording is supplemented with continual reporting from staff at Stevns Municipality and Østsjælland's Museum as well as plot owners and local residents.

The monitoring report is evaluated by the Steering Group Stevns Klint that assesses whether the geological value is sufficiently protected or adjustments have to be implemented.

Communication

Restriction to fossil collection in Denmark is highly uncommon and Stevns Klint has been a popular fossil collecting site. However, the monitoring programme has detected no severe damage to the cliff.

In order to ensure a general understanding and support for the guidelines the communication is conducted gradually in a two year programme.

In the winter 2013/2014 information meetings are held between each local amateur fossil collecting association and a geologist from Østsjælland's Museum and the guidelines are well received by the associations visited so far. A spokesperson from each association is invited to join a formal working group regarding all aspects of communication and enforcement of the guidelines and is expected to lead to new ideas of how to communicate the guidelines.

Communication of the guidelines to professional geologists will be executed following advice from the Geological Reference Group that will be formed in autumn 2014 as part of the local organisation on Stevns Klint.

Communication to the local community will be through the Local Reference Group and articles in local newspapers.

Communication to the general public is performed in two phases. In 2014 the promotion of Stevns Klint as a fossil collection sites is stopped. From 2015, when the guidelines are well known to locals, amateur geologist and professional geologists, the guidelines will be communicated to the general public on existing signs along the cliff, on all printed material and websites from the Tourist Association and Østsjælland's Museum.

Question 3c – Appendix 1

Guidelines for collecting samples and fossils along and in Stevns Klint

1. Background

By agreement between Gjorslev Manor (Gjorslev Gods), Stevns Municipality and Østsjælland Museum, effective from 1 February 2012, Stevns Municipality and Østsjælland Museum are to prepare and communicate a set of guidelines that will regulate the collection of samples, fossils and other geological materials along and in Stevns Klint in order to secure Stevns Klint as a site of geological value and to secure the ownership of Gjorslev Manor to the cliff.

The guidelines below have been prepared by Stevns Municipality and Østsjælland Museum and have been approved by Gjorslev Manor and the Steering Group Stevns Klint.

2. Delimitation of the area

The present guidelines are applicable to the area of Stevns Klint that has been nominated as a UNESCO World Heritage site. The area's delimitation is described in the supplementary materials for the official application for inscription of Stevns Klint as a UNESCO World Heritage site.

The area includes the cliff's vertical surfaces and the beach terrain above the daily water level (cf. the application's figure 2).

The area is the property of Gjorslev Manor.

Within the area, three subareas have been selected for which more stringent guidelines apply. These are the section from Rødvig to Korsnæb, the section in Kirkevig (Højerup), and the profile in Boesdal Kalkbrud (abandoned quarry).

Holtug Kridtbrud (abandoned quarry) is owned by the State. The Danish Nature Agency establishes separate guidelines for collection of geological materials in Holtug Kridtbrud.

Boesdal Kalkbrud (abandoned quarry) is owned by Stevns Municipality. The present guidelines are also applicable to Boesdal Kalkbrud.

The property with land register number 34-1 Holtug is privately owned and guidelines are agreed separately with the owner.

3. Acts and regulations concerning collection of geological materials along Danish beaches

Regulations concerning collection of materials along the Danish beaches are partly set out in the Act on the Protection of Nature and in the Act on Raw Materials. However, neither of the two Acts is specific about the form and extent of the collection of materials that are permitted along beaches.

The present guidelines are therefore based on the Danish Nature Agency's interpretation of the applicable legislation concerning rights to collect materials along Danish beaches and on private land.

Similarly, Danish legislation does not provide clear regulations about extraction of materials. In this connection, extraction is understood as any digging og "prospecting" of materials from the cliff surface by hand or with the use of tools, whether a subsequent collection takes place or not.

The present guidelines are therefore based on the area being privately owned and the cliff face and the materials being private property.

4. Specific conditions at Stevns Klint

The cliff face and the foreshore of Stevns Klint are private property of Gjorslev Manor. Therefore Gjorslev Manor has legal authority to prohibit extraction and collection of materials from the area referred to, but through these present guidelines, Gjorslev Manor gives a general dispensation for collection to take place in accordance with the guidelines.

Stevns Klint is a UNESCO World Heritage candidate. The candidacy or inscription on UNESCO's World Heritage List do not as such guarantee legal protection of the cliff, nor do they impose limitations to the

possibilities for taking and collecting geological materials. However, the candidacy does imply that compliance with the guidelines is to be monitored.

5. General guidelines

The following general guidelines apply to extraction and collection of fossils, samples or other geological materials in the area referred to.

1. No digging, hammering or drilling or any other ways of taking samples from the cliff surface with the use of tools are permitted.
2. Fossils, samples and other geological materials may be collected from material that has fallen down onto the beach. The amount of collected material may not exceed that which can be removed without auxiliary equipment.
3. Unique geological materials that may be considered *Danekræ* (fossil troves) belong to the Danish State pursuant to the Museum Act and may not be removed; such findings should be reported or submitted to the Natural History Museum of Denmark or to the state-approved natural history museum, Østsjællands Museum, which is the geological museum authority in the field. Østsjællands Museum will then handle submitted materials pursuant to the provisions of the Museum Act.
4. Collecting or collected samples, fossils or other geological materials may not be made the object of commercial purposes, including sales of materials.

Dispensation from the above guidelines is subject to prior permission from Gjorslev Manor as the owner and from Stevns Municipality as the administrative authority in relation to the Act on the Protection of Nature and the Act on Raw Materials. Any request for dispensation must be submitted to the Stevns Klint Development Group, which will present the request to the relevant authorities.

6. Special guidelines concerning collection for scientific purposes

Extraction and collection of fossils, samples or other geological materials from the area referred to for scientific purposes that require the use of tools, collection of large amounts of material or extraction of materials from the cliff surface are subject to prior permission.

Any request for permission must be submitted to Østsjællands Museum, which is the geological museum authority in the field. The request must include the following:

- A reasoned explanation for the intended extraction or collection
- Indication of collection methods
- Indication of collection place
- Indication of end user of the collected materials

The request will be processed by Østsjællands Museum.

7. Special guidelines concerning collection in protected areas

In order to secure Stevns Klint as a site of geological value against damage caused by visitors, the following guidelines – in addition to the general guidelines – apply to the three specially selected areas.

The area in Kirkevig:

- No geological materials may be collected from the cliff surface.
- No geological materials may be collected from fallen materials, including from blocks on the beach, with the use of tools.

The area between Rødvig and Korsnæb:

- No geological materials may be collected from the cliff surface.

The area by the profile in Boesdal Kalkbrud (abandoned quarry):

- No geological materials may be collected from the profile.

Reference is made to the enclosed map appendix about the delimitation of the areas in question.

9. Communication

Stevns Municipality, in collaboration with Østsjælland Museum, handles communication of the present guidelines to the public, including answering questions about the guidelines and their reasoning.

Communication takes place via relevant and adequate information materials, including in printed pamphlets, through signage at relevant places and via the Internet.

Additional communication is aimed directly at specific groups, including tour operators, fossil collector groups, institutions and researchers.

Communication takes place in Danish, German and English.

10. Period of validity

The present guidelines are valid through to 1 February 2017.

Gjorslev Manor, Steering Group Stevns Klint, Stevns Municipality and Østsjælland Museum may demand a review of the guidelines at three months' notice within the agreement period.

11. Approval

Stevns Municipality

Østsjælland Museum-

Gjorslev Manor (Gjorslev Gods)

Steering Group Stevns Klint