R-08-05

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Site descriptive modelling SDM-Site Laxemar

Gustav Sohlenius, Anna Hedenström
Geological Survey of Sweden (SGU)

November 2008

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ISSN 1402-3091
SKB Rapport R-08-05

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Preface

The Swedish Nuclear Fuel and Waste Management Company (SKB) is undertaking site characterisation at two different locations, the Forsmark and Laxemar-Simpevarp areas, with the objective of siting a geological repository for spent nuclear fuel. The site investigations started in 2002 and were completed in 2007. The analysis and modelling of data from the site investigations provide a foundation for the development of an integrated, multidisciplinary Site Descriptive Model (SDM) for each of the two sites. A site descriptive model constitutes a description of the site and its regional setting, covering the current state of the geosphere and the biosphere, as well as those natural processes that affect or have affected their long-term development. The site descriptions shall serve the needs of both Repository Engineering and Safety Assessment with respect to repository layout and construction, and its long-term performance. The descriptions shall also provide a basis for the Environmental Impact Assessment.

The surface system consists of a number of disciplines that have been organised and worked together within the project group SurfaceNet. The disciplines involved in the description are:

- hydrogeology, surface hydrology and oceanography,
- bedrock- and Quaternary geology and soil-science,
- hydrogeochemistry and surface water chemistry,
- system- and landscape ecology,
- nature- and human geography.

Focus for the description has, beside a general description of site conditions, been to support and answer a few overall questions, such as:

- What types of ecosystems are present and how do they function in terms of transport and accumulation of matter at a local and regional scale?
- How has the site developed over time?
- Can we find evidence for deep groundwater discharge, and describe the processes involved?

Previous versions of these site descriptions have been published for both Forsmark and Laxemar-Simpevarp. The latest version of the overall concluding site description, SDM-Site, is found in the SDM reports /SKB 2009/. Further, a more comprehensive overall surface system description of Forsmark and Laxemar-Simpevarp, respectively, is found in the two Surface system reports /Lindborg 2008, Söderbäck and Lindborg 2009/.

The report you are about to read comprises a final description of soils and Quaternary deposits (regolith) in the Laxemar-Simpevarp area.

Tobias Lindborg

Project leader, SurfaceNet

Abstract

This report compiles all known available information regarding the regolith in the Laxemar-Simpevarp regional model area. Regolith refers to the loose deposits overlying the bedrock. In the Laxemar-Simpevarp area, all known regolith was deposited during the Quaternary period and is consequently often referred to as Quaternary deposits (QD). In the terrestrial areas the uppermost part of the regolith, which has been affected by climate and vegetation, is referred to as soil.

The geographical and stratigraphical distributions of the regolith have been used to construct a model showing the distribution of regolith depths in the whole model area. The stratigraphical units shown in the regolith depth and stratigraphy model have been characterised with respect to physical and chemical properties. Most of the data used for that characterisation have been obtained from the site investigation but some data were taken from the literature.

All QD in the Laxemar area have most probably been deposited during or after the latest deglaciation. The ice sheet in the area moved from the north-west during the latest ice age. The Baltic Sea completely covered the investigated area after the latest deglaciation c 12,000 BC. Land uplift was fastest during the first few thousand years following the deglaciation and has subsequently decreased to the present value of 1 mm/year. Older QD have been eroded in areas exposed to waves and currents and the material has later been redeposited. Fine-grained sediments have been deposited on the floor of bays and in other sheltered positions. Peat has accumulated in many of the wetlands situated in topographically low positions. The groundwater table in many of the former wetlands has been artificially lowered to obtain land for forestry and agriculture, which has caused the peat to partly or completely oxidise. As land uplift proceeds, some new areas are being subjected to erosion at the same time as other new areas are becoming lakes and sheltered bays where fine-grained sediments can accumulate.

The distribution of QD's on both land and sea areas is shown on a map over the whole Laxemar-Simpevarp regional model area. Data obtained from several investigations have been used to produce that map. The accuracy of the map therefore varies and the most detailed information was obtained from the central part of the model area.

The geographical distribution and depth of the QD is largely determined by the topography of the underlying bedrock. Areas with exposed bedrock and a thin till cover dominate the whole regional model area, including the sea floor. These areas are crossed by a number of fissure valleys where the regolith cover is considerably thicker. Glacial clay with a thin cover of sand is the dominating surface deposit in the valleys on the sea floor. In the bays and land areas, the valleys are dominated by clay gyttja, which at many locations in the terrestrial areas is covered by a thin layer of peat. There are several glaciofluvial deposits, with a north strike, in the investigated area. The Tuna esker in the western part of the model area is the largest of these deposits. In a morphological sense, that esker is the most significant QD in the model area. In certain areas the till has a more coherent distribution than in the area in general. These areas are characterised by hummocks, which are probably not due to the morphology of the underlying bedrock.

The properties of soils have been classified at sites representing ten land classes. These results were used together with the QD map and other geographical information to produce a soil-type map over the terrestrial part of the model area. Podsol, Leptosol and Regosol are the most commonly occurring soil types in the area. Wetlands and areas used as arable land, i.e. for cultivation of crops, are to a large extent covered by different types of Histosol.

Most data showing the total depth of the regolith cover were obtained from geophysical investigations. The stratigraphical distribution of QD was obtained from drilling and excavations. The results show that the stratigraphical distribution of QD in the investigated area is rather uniform. Till is the oldest QD in the area, and is subsequently resting directly upon the bedrock surface.

The till in the valleys is often overlain by glacial clay, which in many valleys is overlain by a thin layer of sand followed by clay gyttja and peat.

The most common QD have been analysed with respect to grain size distribution. Porosity and density has been calculated for some of the QD. Data from the literature have been used for the QD when site-specific data necessary for calculating these values are not available. The till has a low content of fine material and is dominated by sand and gravel. In some of the valleys the till underlying the clay is surprisingly well sorted with respect to grain size.

The contents of elements in the regolith from the Laxemar area are close to the Swedish averages. The petrographical and mineralogical composition of the till reflects that of the local bedrock even though the till has been transported from the north. Since the till has been subjected to chemical weathering, the chemical composition of the till differs slightly from that of the bedrock. The mineralogy of the clay is different from that of the bedrock since the clays have a high content of clay minerals, which were formed by chemical weathering of primary rock-forming minerals. The chemical composition of the clay is also affected by the environmental conditions prevailing during deposition.

Sammanfattning

I denna rapport sammanställs all tillgänglig information som berör regolit i Laxemar-Simpevarps regionala modellområde. Med regolit menas alla de lösa avlagringar som överlagrar berggrunden. All känd regolit i Laxemarområdet har avsatts under kvartärtiden och kallas därför ofta för kvartära avlagringar. I Sverige används oftast termen jordart för att beskriva olika typer av kvartära avlagringar. Närmast markytan har jordarternas egenskaper påverkats av klimat och vegetation. Denna övre del av jordtäcket kallas i landområdena för jordmån.

Jordarternas geografiska och stratigrafiska fördelning har använts för att framställa en jorddjupsmodell över hela modellområdet. De olika stratigrafiska enheter som presenteras i jorddjupsmodellen har karaktäriserats med avseende på deras kemiska och fysikaliska egenskaper. Denna karaktärisering bygger i första hand på data från Laxemarområdet men i vissa fall har litteraturuppgifter använts.

De kvartära avlagringarna i Laxemarområdet har troligen helt avsatts under eller efter den senaste nedisningen. Den senaste inlandsisen rörde sig från nordväst över området. Hela Laxemarområdet var nedpressat under Österjöns vattenyta då inlandsisen försvann från området för ca 14,000 år sedan. Landhöjningen var snabbast under årtusendena efter isavsmältningen och har därefter avklingat för att idag vara ca 1 mm/år. I områden som exponeras för vågor och strömmar har tidigare avsatta jordarter eroderat och omlagrats till mer skyddade lägen. I vikar och andra skyddade lägen har finkorniga sediment avsatts. I många sänkor finns våtmarker där torv ackumulerats. Många tidigare våtmarker har dock dikats för jord och skogsbruk, vilket lett till att torven helt eller delvis oxiderat bort. Allt eftersom landhöjningen fortskrider utsätts nya områden för erosion samtidigt som vikar och sjöar uppstår där finkorniga sediment kan ackumulera.

De kvartära avlagringarnas fördelning i både landområden och områden som utgörs av sjöar och hav har sammanställts på en karta över hela Laxemar-Simpevarps regionala modellområde. Denna karta har framställts genom att kombinera resultat från en rad undersökningar. Kartans noggrannhet varierar därför och är som störst i modellområdets centrala delar.

Jordarternas fördelning och mäktighet styrs till allra största delen av den underliggande bergytans topografi. Hela det regionala modellområdet, inklusive havsområdena, domineras av områden med hällmark och tunt moräntäcke. Dessa områden genomkorsas av ett antal sprickdalar, där jorddjupet är betydligt större. I dalgångarna till havs är glaciallera som överlagras av ett tunt sandskikt den dominerande kvartära avlagringen. I vikar och landområden domineras dalgångarna istället av lergyttja som på land ofta täcks av ett tunt lager av torv. I området finns flera isälvsstråk med en nordlig sträckning. Tunaåsen i modellområdets västra del är den största av dessa isälvsavlagringar och utgör den morfologiskt sett mest signifikanta kvartära avlagringen i hela det undersökta området. I vissa områden har moränen en mer sammanhängande utbredning än vad som är typiskt för området. Dessa områden kännetecknas av småkulliga former vilka antagligen inte återspeglar den underliggande berggrundens morfologi.

Områdets jordmåner har klassificerats på platser som representerar tio olika marktyper. Dessa resultat har sedan använts tillsammans med jordartskarta, vegetationskarta och annan geografisk information för att framställa en jordmånskarta över landområdena. Podsol, leptosol och regosol och är de vanligaste jordmånerna i området. Våtmarker och jordbruksmark täcks till stor utsträckning av olika typer av histosol.

Data som visar regolitens totala mäktighet kommer till största delen från geofysikundersökningar. Den stratigrafiska fördelningen av de kvartära avlagringarna har beskrivits i ett flertal borrningar och grävda schakt. Resultaten visar att området har en relativt enhetlig stratigrafi. Morän är den äldsta och därmed närmast berget liggande jordarten. I dalgångarna överlagras moränen ofta av glaciallera som i sin tur många gånger överlagras av sand, följt av lergyttja och torv.

De vanligaste jordarterna har analyserats med avseende på kornstorleksfördelning. I de fall det funnits data har jordarternas porositet och densitet beräknats. I vissa fall saknas sådan data och uppgifter från litteraturen har därför använts. Moränen innehåller endast en liten andel finmaterial och domineras av sand och grus. Moränen som underlagrar leran i vissa av dalgångarna har visat sig vara förvånansvärt välsorterad med avseende på kornstorlek.

Jordarterna i Laxemarområdet uppvisar för de flesta grundämnen halter som ligger nära de för Sverige genomsnittliga värdena. Även om moränen transporterats en bit från norr speglar dess petrografiska och mineralogiska sammansättning till största delen den lokala bergrundens. Eftersom moränen utsatts för kemisk vittring skiljer sig dock den kemiska sammansättningen något från berggrunden. Lerorna har en mineralogi som skiljer sig från berggrundens eftersom dessa till stor del består av lermineral vilka bildats efter vittring av primära bergartsbildande mineral. Den kemiska sammansättningen hos lerorna är dessutom till stor del påverkad av de förhållanden som rått då dessa sediment en gång avsattes.

Contents

1 Introduction

This report reviews all known available data concerning the properties of the regolith in the Laxemar-Simpevarp regional model area. Regolith refers to the unconsolidated material overlying the bedrock. In this report the term Quaternary deposits (QD) is often used since all known regolith in the Laxemar-Simpevarp area was formed during the Quaternary period (the last 2.6 million years). The regolith includes marine and lacustrine sediments, peat and glacial deposits. In terrestrial areas the upper part of the regolith is referred to as the soil. In this report the term soil is therefore used to describe the upper c 0.5 metre of the regolith in the terrestrial areas, whereas the term Quaternary deposits is used when discussing the regolith below that level. Soils are formed by the interaction of the regolith with climate, hydrology and biota. Different types of soils are characterised by diagnostic horizons with special chemical and physical properties. Knowledge of the composition of QD and soils is of importance for an understanding of the hydrological, chemical and biological processes taking place in the uppermost geosphere.

The objectives of this report are to:

1) Construct models of the surface and stratigraphical distribution of regolith in the Laxemar-Simpevarp regional model area.
2) Characterise the chemical and physical properties of the regolith in the model area.

The regolith models are used as input for modelling hydrological, chemical and biological processes taking place in the uppermost geosphere /e.g. SKB 2006a, Werner et al. 2005/. The properties of the regolith in the discharge areas are of special interest since groundwater from the deeper bedrock may reach the surface through the regolith in these areas. Several of the site investigations have therefore been focused on the distribution of regolith in wetlands and areas covered by water.

The term Laxemar-Simpevarp regional model area is used in this report when discussing the specific model area shown in Figure 2-1. The term Laxemar-Simpevarp area is used for discussing the area in general.

In this report, knowledge of the past Quaternary environments is used to explain the current distribution of QD. For a thorough description of the Quaternary development of the Laxemar-Simpevarp, the reader is referred to /Söderbäck 2008/.

Figure 1-1 shows the reports that have been or will be produced for the Site Description Models (SDM) of Laxemar-Simpevarp. The overall concluding site description, SDM-Site, is found in the level I SDM report /SKB 2009/. Further, a more comprehensive overall surface system description of Laxemar-Simpevarp is found in /Söderbäck and Lindborg 2009/.

A previous version of this report was read by Bernt Kjellin (SGU), Kent Werner (EmpTec), Regina Lindborg (NaturRådet), Raymond Munier (SKB), Johan Stendahl (SLU) and Per-Arne Melkerud (SLU). They all contributed comments that improved the manuscript.

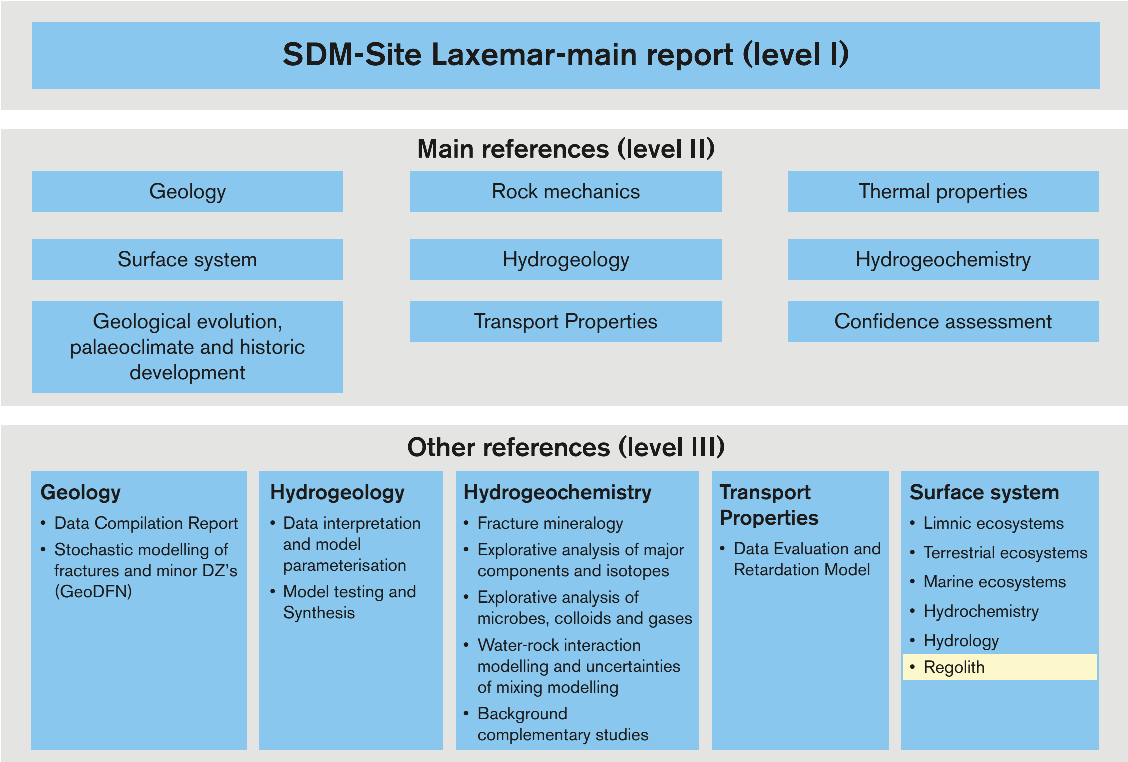


Figure 1-1. *Structure of the reports produced to serve as a basis for the Site Descriptive Models for Laxemar-Simpevarp. The present report is marked with yellow.*

2 Input data

Data about the regolith in the Laxemar-Simpevarp regional model area (Figure 2-1) were collected during several campaigns. Data concerning the surface distribution of Quaternary deposits (QD) were obtained from several surveys in the regional model area (Table 2-1, Figure 2-2). The results were used to produce a map showing the surface distribution of QD in the whole regional model area. The stratigraphical distribution and total thickness of the regolith were investigated within several activities (Figures 2-3 and Table 2-2). Data available at data freeze Laxemar 2.2 were used to model the stratigraphy and total depth of regolith in the Laxemar-Simpevarp area (Figure 2-4).

Table 2-3 summarises data used for modelling the chemical and physical properties of the regolith. Figures 2-5 and 2-6 show the geographical distribution of the samples used for these analyses. Those data were also used for modelling the stratigraphical distribution of Quaternary deposits and for a general understanding of the Quaternary development of the Laxemar-Simpevarp area. Soil data were used together with other geographical data to produce a soil type map of the terrestrial part of the regional model area. Data from reports that are not included in the SKB site investigation are shown in the reference list.

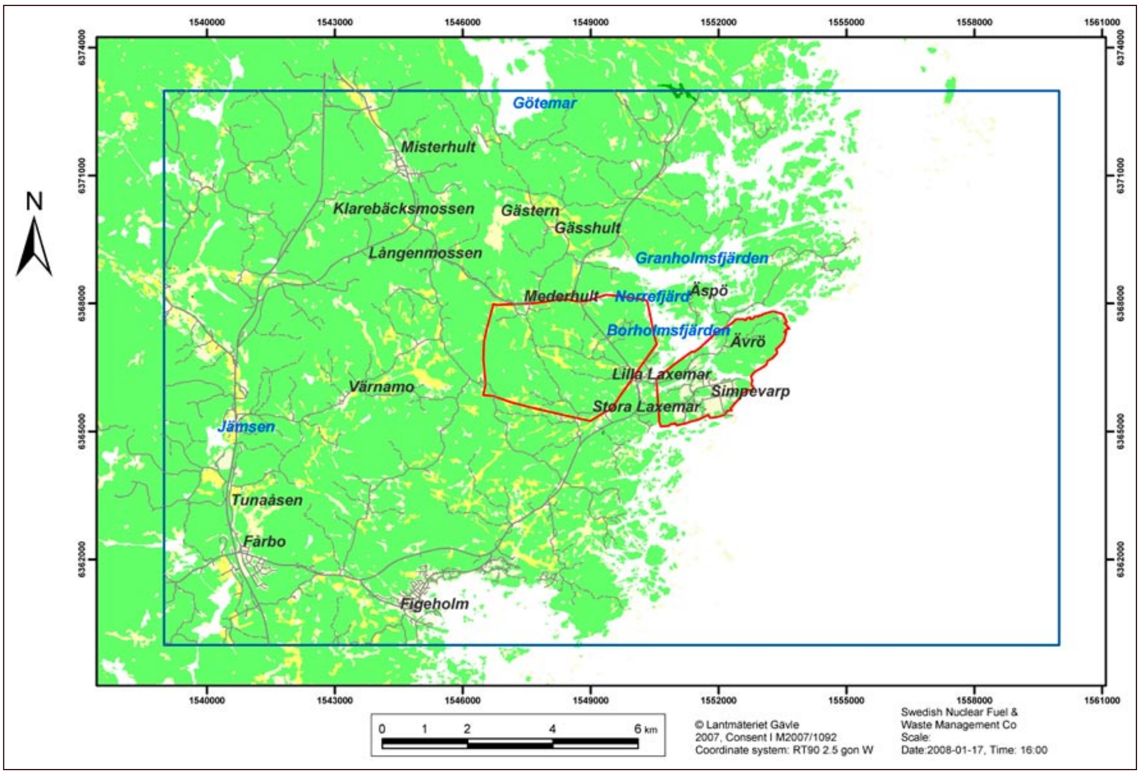


Figure 2-1. *The Laxemar-Simpevarp regional model area and the location of sites mentioned in the text. The boundary of the model area is marked with a dark blue line. The boundaries of the Laxemar and Simpevarp subareas are marked with a red line on the map.*

Table 2-1. Short description and references to the data used to produce the QD map of the regional model area. The geographical distribution of the different areas is shown in Figure 2-2. T = terrestrial areas, M = marine areas, L= lakes. The digital aerial photos were used to interpret the distribution of QD on land. The digital elevation model (DEM) was used for the regolith depth and stratigraphy model.

Area	Type of data	Reference
1 (T)	Detailed information for presentation on a scale of 1:10 000	SKB-P-05-49
2 (T)	Information for presentation on scale of 1:50 000	SKB-P-05-49
3 (T)	Interpretations from aerial photos and field checks	SKB-P-05-49
4 (T)	Interpretations only from aerial photos	SKB-P-05-49
5 (M)	Detailed marine information (SGU, line spacing 100 m)	SKB-P-05-35 modified by Kjellin 2007 (SGU report)
6 (M)	Local marine information (SGU, line spacing 1 km)	SKB-P-05-35 modified by Kjellin 2007 (SGU report)
7 (M)	Local marine information (SGU and MMT*)	SKB-P-05-35/ SKB P-04-254 modified by Kjellin 2007 (SGU report)
8 (M)	Mapped from SGU's regular survey programme	Kjellin 2007 (SGU report)
9 (M)	Mapped by MMT*	SKB P-04-254 modified by Kjellin 2007 (SGU report)
10 (M/L)	Interpreted from bathymetry and surrounding geology (SGU)	Kjellin 2007 (SGU report)
11 (L)	Interpreted from surrounding geology and bathymetry	Sohlenius (no report)
All areas	Digital Elevation Model (DEM)	P-04-03
		R-05-38
All areas	Digital aerial photos	P-02-02

* Marin mätteknik.

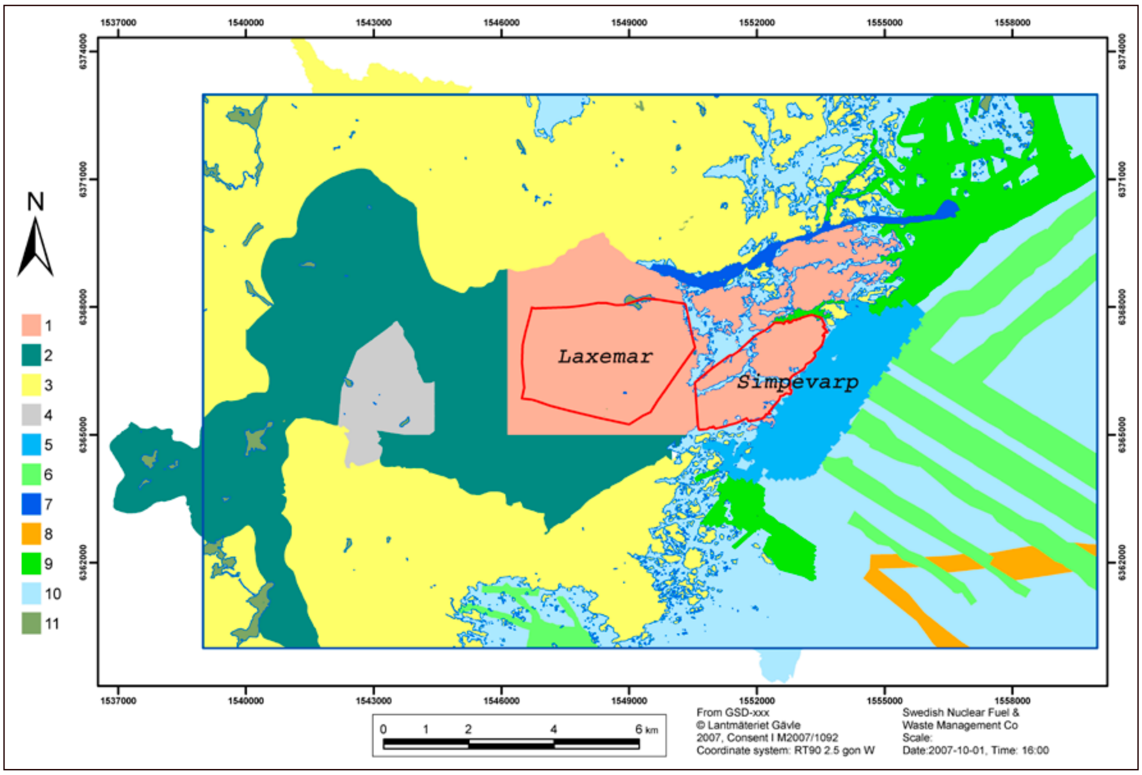


Figure 2-2. *The QD map was produced by means of several methods represented by different colours on the map. The methods used for the different areas are explained in the text and in (Table 2-1). The boundaries of the Laxemar and Simpevarp subareas are marked with a red line on the map and the boundary of the Laxemar-Simpevarp regional model area is marked with a dark blue line. A regolith depth and stratigraphy model was produced for the whole area mapped for QD. In addition, a soil type map covering the whole terrestrial part of the regional model area was produced by /Lundin et al. 2005/.*

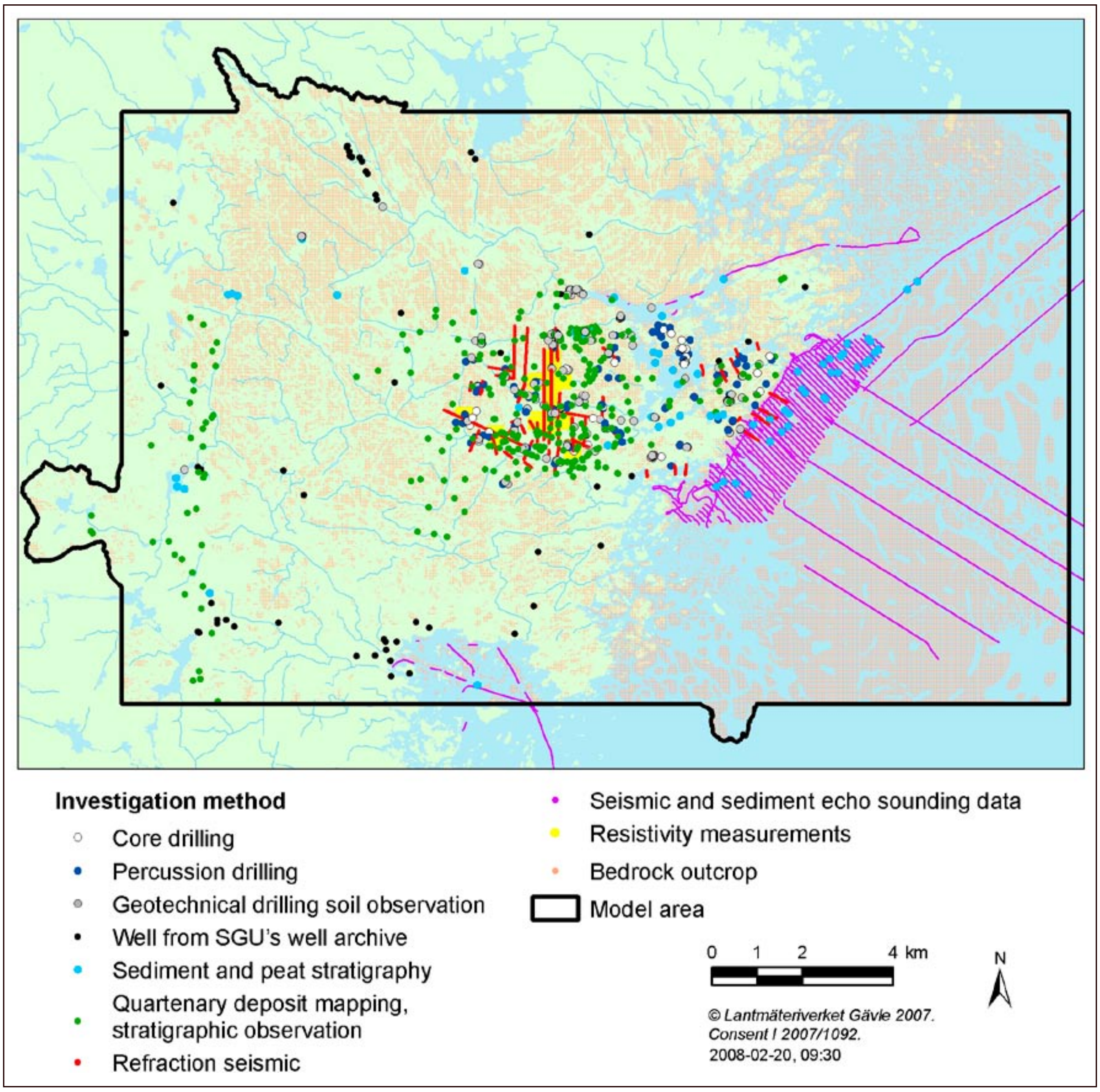


Figure 2-3. *Data used by /Nyman et al. 2008/ for modelling the surface and stratigraphical distribution of Quaternary deposits in the Laxemar area. Data from the marine areas mapped by /Elhammer and Sandkvist 2005/ include stratigraphy and total depth data of regolith from 138,571 points. The refraction seismic and resistivity transects include regolith depth data from a total of 2,860 and 10,971 points, respectively.*

Table 2-2. Data used for modelling the depth and stratigraphy of the regolith depth and stratigraphy model /Nyman et al. 2008/. The geographical location of the sites is shown in Figure 2-3.

Data	Description	No. of observations	Reference
Refraction seismic data	Each observed point along the transects has coordinates, a surface elevation and an estimated smoothed bedrock elevation	51 transects including 2,860 observation points	P-04-134, P-04-201, P-04-298, P-05-155, P-06-49
Detailed geophysical measurements: resistivity measurements	Each observed point along the transects has coordinates and an estimated regolith depth	10,971 observations	P-03-17 P-06-284
Vertical electrical soundings (VES)	Observation points from vertical electrical soundings (VES) where a estimated depth to bedrock is used	49 observation points	P-06-284 P-03-17
Seismic and sediment echo sounding data	Data include estimated depth to bedrock and stratigraphy for each site.	138,571 sites	P-05-35
Quaternary deposit mapping and observations of stratigraphy	Mostly shallow observation points with detailed information of stratigraphy	303 observations	P-05-47, P-05-49, P-06-121
Inorganic sediment mapping and peat land mapping	Information on stratigraphy	44 observations	P-04-273
Ocean sediment core sampling	Information on stratigraphy	37 observations	P-05-35
Geotechnical drilling soil observations	Stratigraphy and regolith depth from drilling and weight sounding	189 observations	P-04-121,P-04-317, P-06-248, P-07-91, P-06-121
Percussion drilling	Regolith depth from percussion drilling in bedrock	93 observations	*
Core drilling	Regolith depth from core drilling in bedrock	37	*
Cored, percussion and probe boreholes	Boreholes with an estimated bedrock elevation, i.e. cored, percussion and probe boreholes	319 boreholes	
The SGU well archive	Private wells mapped by SGU. Data includes depth to bedrock. The quality of the coordinates in the well archive is quite varied	57 wells	/SGU 2007/

* These observations are compiled from numerous reports which are not shown here.

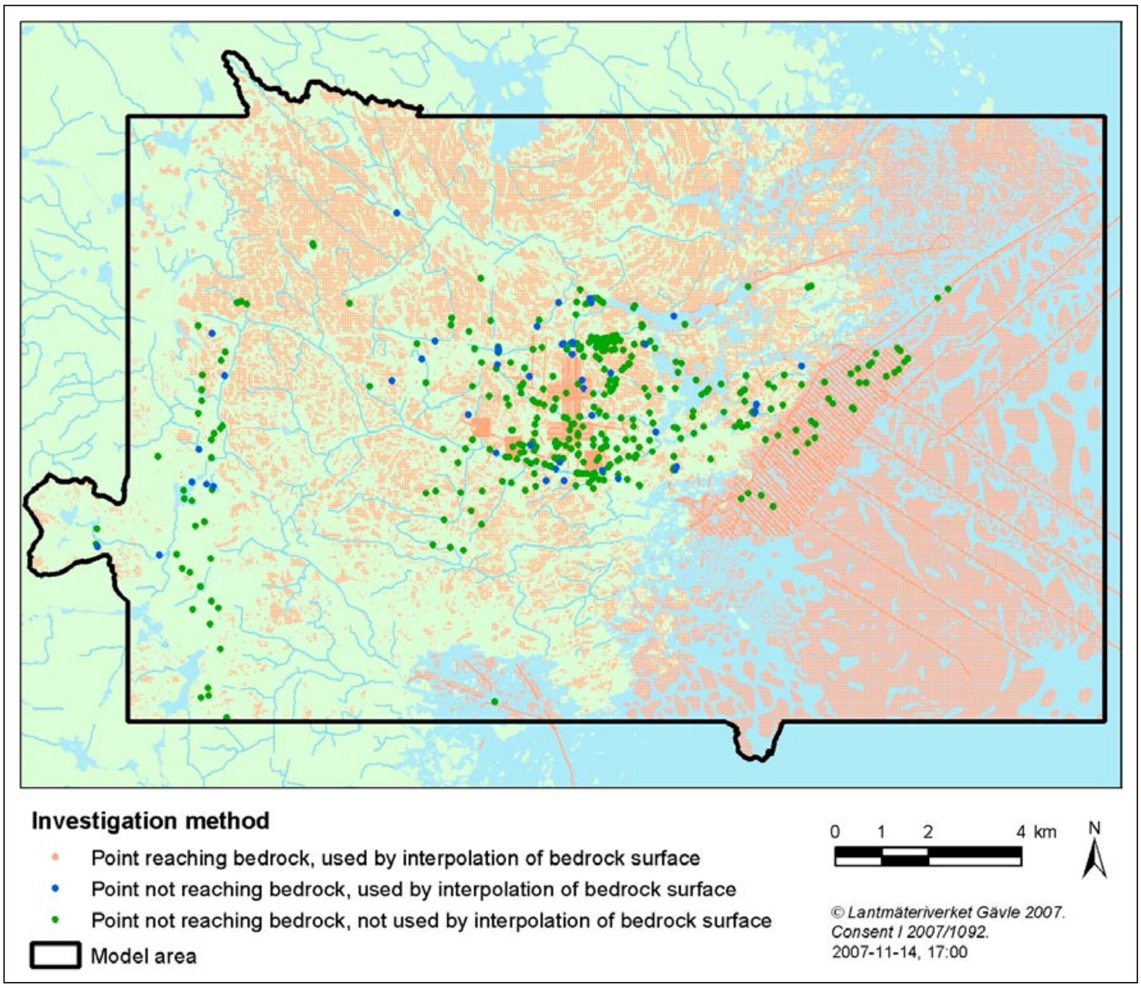


Figure 2-4. *Data used for the interpolation of the bedrock surface and calculation of regolith depths /Nyman et al. 2008/.*

Table 2-3. Available data used for modelling the properties of the regolith. Certain data were used for a general understanding of the Quaternary development of the Laxemar-Simpevarp area.

Available site data Data specification	Usage in Analysis/Modelling	Ref.
Map of QD in the Laxemar-Simpevarp regional model area (Table 2-1).	Description of surface distribution of QD in the Laxemar-Simpevarp regional model area. Quaternary development of the area.	P-04-22, P-04-254, P-05-35, P-05-49, P-06-296
Map of soils in the terrestrial part of the Laxemar-Simpevarp regional model area.	Distribution of soil types in the Laxemar-Simpevarp regional model area.	P-04-243, R-05-15
Deposits on the bottom of water-courses.	Evaluation of the QD map.	P-05-40
Stratigraphy and total depth of QD from the sea and lake floors.	Description of stratigraphy and total depth of QD on the sea floor. Quaternary development of the area.	R-02-47, P-04-254 P-04-273,P-05-3 5 P-06-121, P-06-144
Stratigraphy and total depth of QD in the terrestrial areas.	Description of stratigraphy and total depth of regolith in the terrestrial parts of the Simpevarp and Laxemar subareas. Quaternary development of the area.	P-03-80, P-04-22 P-04-121, P-04-317 P-05-49, P-05-47 P-06-121, P-07-91
Stratigraphical studies outside the Laxemar-Simpevarp regional model area.	Stratigraphy of QD in the Laxemar-Simpevarp area. Quaternary development of the area.	P-04-192, P-05-232 P-06-160
Bedrock geology.	Mineralogical composition of the regolith.	P-05-180
Physical properties of QD.	Physical properties of Quaternary deposits.	P-04-243, P-04-273 P-05-49, P-04-17 R-02-47, R-05-15 P-07-91, P-06-121
Dating of sediment and peat.	Accumulation rates of sediment and peat.	P-06-301, P-06-250
Chemical and mineralogical analyses of QD.	Chemical and mineralogical analyses of QD.	P-04-273, P-05-49 R-02-47, R-04-72 R-05-15, R-06-18 P-06-121, P-05-35 P-07-30, P-06-301 P-06-320, P-06-321, P-07-222

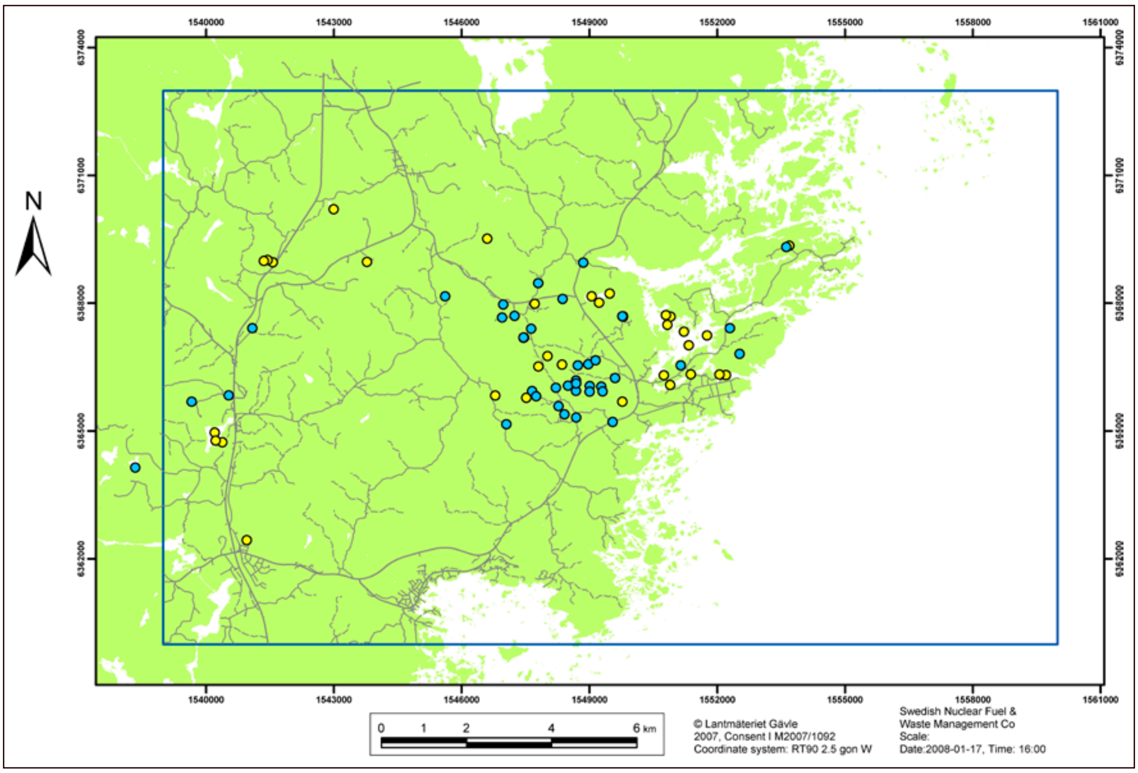


Figure 2-5. *Distribution of sites where samples for grain size analyses were taken. Blue circles represent sites where till samples were analysed. Yellow circles represent sites where water-laid sediments were analysed.*

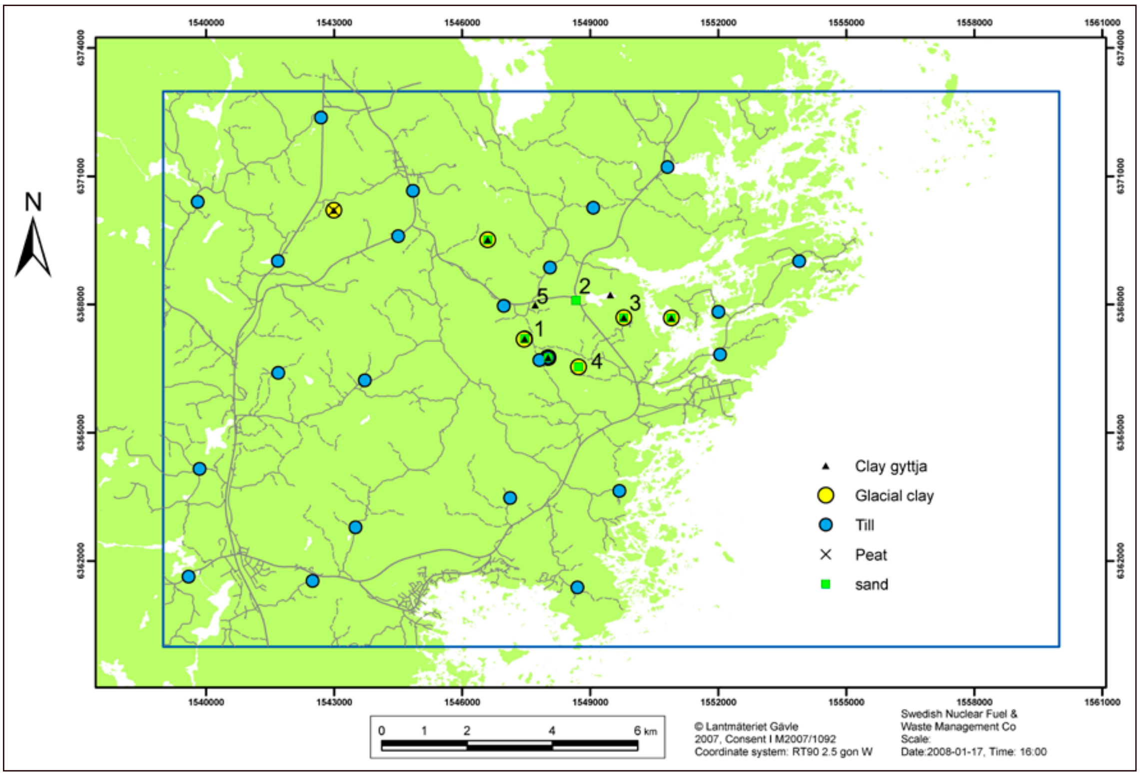


Figure 2-6. *Distribution of sites where samples for geochemical analyses were taken. The stratigraphical profiles (1-5) investigated by /Sohlenius et al. 2006/ are also shown in the figure.*

3 Conceptual model

3.1 The Quaternary deposits

All known regolith in the Laxemar-Simpevarp regional model area was formed during the Quaternary Period and is therefore often referred to in the present report as Quaternary deposits (QD). Most QD were formed during or after the latest glaciation. In the Laxemar-Simpevarp area, the latest deglaciation occurred c 12,000 years BC /Lundqvist and Wohlfarth 2001/. Due to the pressure of the ice sheet, large parts of Sweden, including the whole of the Laxemar-Simpevarp regional model area, were covered by water after the deglaciation. In Sweden the highest altitude covered by water in an area is referred to as the highest shoreline (Figure 3-1). The highest level covered by the brackish Littorina Sea (7500 BC-present) is in this area referred to as the marine limit (Figure 3-1).

The QD are subdivided in two main groups according to genesis and depositional environment: glacial and postglacial deposits. For a thorough description of the genesis and distribution of QD in Sweden, the reader is referred to /Lindström et al. 2000/ and /Fredén 2002/.

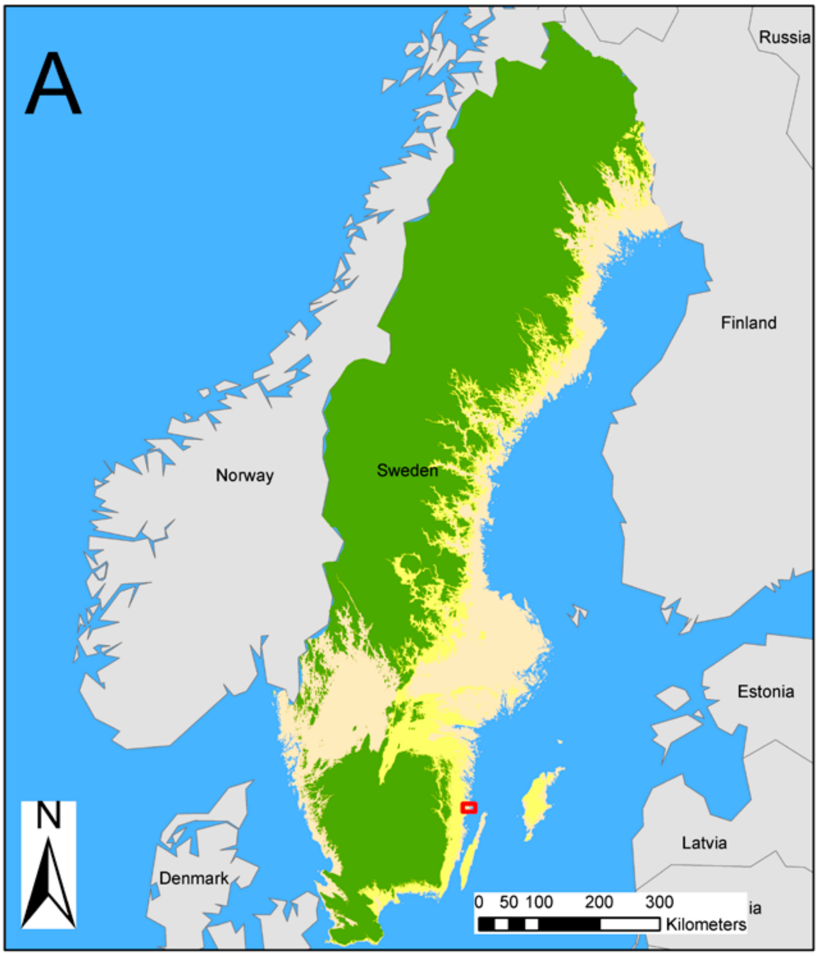
Glacial deposits were deposited either directly from the ice sheet or by the meltwater from this ice. The glacial till was deposited directly by the glacier ice. Till is the most common type of QD in Sweden and often contains all grain sizes from clay particles to large boulders. The grain size distribution of till may differ depending on the physical properties of the local bedrock, the properties of older regolith and the glacial processes involved in the transport and deposition of the till. The ground surface in till areas is often characterised by the occurrence of large boulders. The size and frequency of these boulders vary considerably from area to area. The till matrix is dominated by sand and gravel in most Swedish areas with Precambrian bedrock (e.g. the Laxemar-Simpevarp area). Most areas with sandy and gravelly till are covered by forest.

The meltwater from the ice deposited the glaciofluvial sediments. These deposits comprise coarse material, often forming eskers. Gravel and sand dominate most glaciofluvial deposits. Compared to the glacial till the glaciofluvial sediments are usually well sorted with respect to grain size. Furthermore, the glaciofluvial particles are most often well rounded compared to the till material. The glaciofluvial sediments usually rest directly upon the bedrock surface.

The meltwater from the ice also deposited fine-grained material such as silt and clay. These deposits are referred to as glacial clay or silt and are usually found below the highest shoreline where they form flat fields. Such deposits are often used for cultivation of crops.

Postglacial deposits were formed after the ice sheet had melted and retreated from an area. Postglacial sediment and peat comprise the youngest group of regolith. In general, they overlie till and, locally, glacial clay or bedrock. Clay, organic sediment, peat, sand and gravel dominate the postglacial deposits. Processes forming postglacial deposits have been continuously active since the latest deglaciation.

Postglacial clay was deposited after erosion and redeposition of some of the previously deposited regolith materials, such as glacial clay. The postglacial clay can often be found in the deeper parts of valleys below the highest shoreline. These clay deposits may contain variable amounts of organic material and are then referred to as gyttja, clay gyttja or gyttja clay.



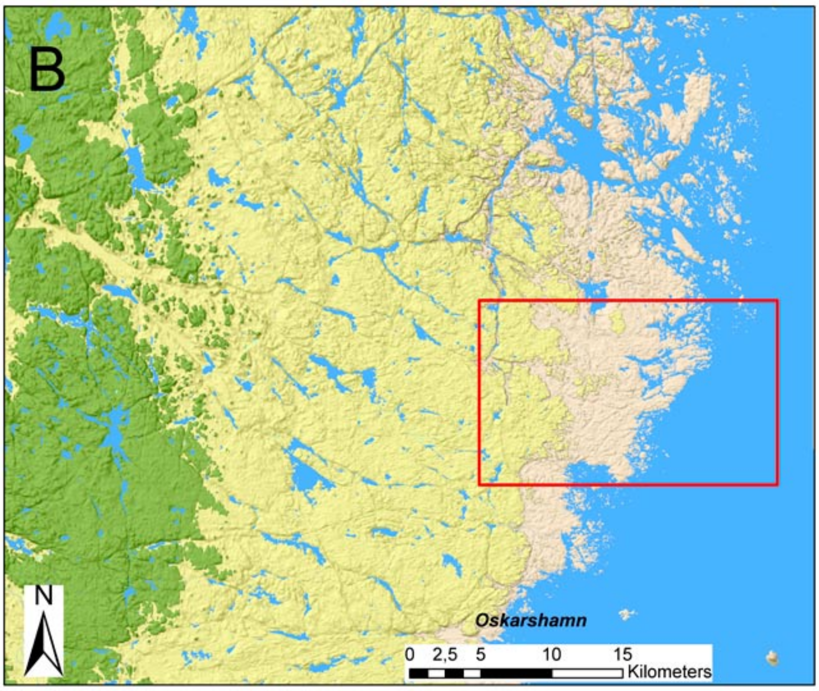


Figure 3-1. *Areas situated below the highest shoreline (yellow and beige) and below the marine limit (beige). The present distributions of sea and lakes are marked with blue. A) The highest shoreline and marine limit in the whole of Sweden. Land areas situated outside Sweden are marked with grey. B) The highest shoreline and marine limit in eastern Småland. The Laxemar-Simpevarp regional model area is marked with a red square in both figures /modified by Jirner-Lindström SGU/.*

Postglacial sand and gravel was deposited by currents and waves, which reworked glaciofluvial deposits and till as the water depth in the sea gradually decreased. The sand and gravel was subsequently deposited in more sheltered positions, usually below the highest shoreline.

Peat consists of remnants of dead vegetation which are preserved in areas (often mires) where the prevailing wet conditions prevent the breakdown of the organic material. Peatlands are often subdivided into fens and bogs. The vegetation in the fens obtains nutrients from the groundwater, whereas a bog obtains nutrients mainly from precipitation. Bogs are therefore poor in nutrients and are characterised by a coherent cover of *Sphagnum* species.

Recent fluvial sediments are deposits that are currently accumulating along watercourses, during high-water occasions.

The typical stratigraphical distribution of QD in areas below the highest shoreline is shown in Figure 3-2. Results from the site investigation performed by SKB suggest that regolith in the Laxemar-Simpevarp area is distributed in a similar way /e.g. Rudmark et al. 2005, Sohlenius et al. 2006a, Nyman et al. 2008/.

In both the marine and terrestrial parts of the Laxemar-Simpevarp regional model area, the distribution of QD is strongly related to the local bedrock morphology. The highest areas have been eroded by the actions of water and/or glacial ice. Exposed bedrock and till dominate these areas. Since the Laxemar-Simpevarp area is situated below the highest shoreline, fine-grained water-laid deposits have accumulated in the long and narrow fissure valleys that are characteristic of the investigated area.

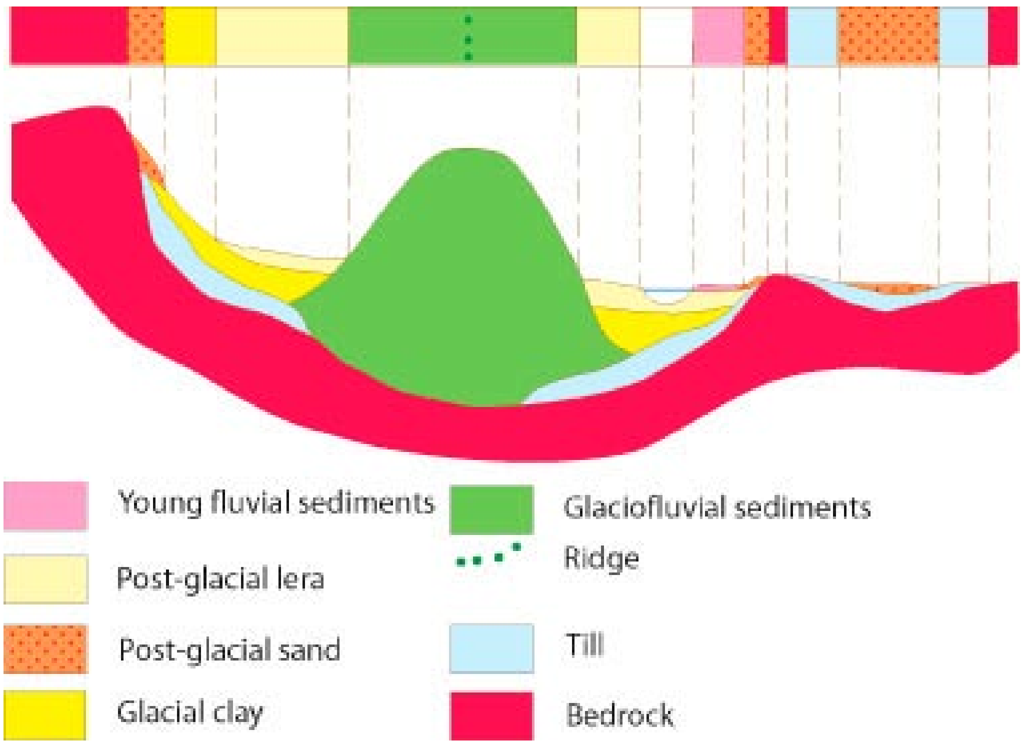


Figure 3-2. *A typical stratigraphical distribution of QD below the highest shoreline. The results presented in this report suggest that the QD in the Laxemar-Simpevarp area have a similar stratigraphy.*

Three type areas have been defined based on the topography and distribution of QD in the Laxemar-Simpevarp area:

I) The topographically high areas, which are dominated by exposed bedrock and till. The till rests directly upon the bedrock surface. In the terrestrial area there are numerous small wetlands covered by peat.

II) The valleys, which are dominated by peat and fine-grained water-laid deposits. The oldest QD in the valleys is till overlain by glacial clay and postglacial sand/gravel, which in some areas is overlain by clay gyttja, and peat. Clay gyttja is currently accumulating on the floors of lakes and bays. Peat is accumulating in the wetlands. Ditches have lowered the ground-water table in many of the former wetlands and the peat is consequently oxidising.

III) The glaciofluvial deposits, which are assumed to rest directly upon the bedrock surface. One relatively large and three small eskers have been recorded in the model area.

3.2 The bedrock in relation to the regolith

The bedrock in the Laxemar-Simpevarp area, as well as in most of southeastern Sweden, is dominated by igneous rocks and belongs to the Transscandinavian Igneous Belt. Most bedrock in the area has a granitic mineral composition.

The inorganic QD consist of more or less altered fragments from the bedrock. The chemical and mineralogical composition of QD in an area can therefore be expected to reflect the composition of the local or nearby bedrock. The sensitivity of soil minerals to chemical weathering is of importance for soil pH and concentrations of nutrients available to the plants. A high percentage of easily weathered minerals, e.g. calcite or amphibole, may consequently be favourable for the vegetation.

A large proportion of the Laxemar-Simpevarp regional model area consists of bedrock outcrops. The mineralogical composition of the local bedrock is most probably reflected in the composition of the nearby till. The mineralogy of the local bedrock is therefore of importance not only for the areas with rock outcrops but also for the soil chemistry in the till. There is a detailed bedrock map (Figure 6-2) covering the Simpevarp and Laxemar subareas with surroundings /Wahlgren et al. 2005/. Data concerning the mineralogical and rock composition of the regolith are included in the present report.

3.3 The soils

The upper part of the regolith is referred to as the soil, which can be characterised by certain chemical and physical properties and has evolved over time through the interaction of soil parent material, climate, hydrology and organisms. Properties of the soils are of crucial importance for the composition and richness of the vegetation. Different soil types are characterised by diagnostic horizons with certain chemical and physical properties. It often takes many thousands of years for soil horizons to develop. In Sweden the soils were formed during the period following the latest deglaciation, which is a relatively short period of time for soil formation. The soils in Sweden are therefore relatively young compared to the soils in many other parts of the world. Many coastal areas in Sweden have been raised above the sea relatively recently. In such areas, too little time has passed for significant soil horizons to develop. The entire Laxemar-Simpevarp regional model area is situated below the highest shoreline. At the lowest altitudes, the time available for soil forming processes has therefore been comparatively short. In the Laxemar-Simpevarp area the soils are shallow and the soil depth is generally less than 0.5 metre.

The following soil horizons are used in the following text, from the ground surface:

The O horizon is the organic surface layer, which is dominated by the presence of large amounts of organic material in varying stages of decomposition.

The A horizon may be darker in colour than deeper layers and contain more organic material. In some soils the lowermost A horizon has been subjected to intense weathering and leaching and has a lighter colour than underlying horizons.

The B horizon is enriched in elements that have been eluviated from overlying horizons. This horizon is often enriched in amorphous iron oxides with or without aluminium compounds.

The C horizon is unaffected or has only been affected to a small extent by soil forming processes.

In the Laxemar-Simpevarp regional model area the following soils were recognised:

1) *Histosol* is a soil type formed from materials with a high content of organic matter. The uppermost organic layer is at least 40 cm thick. Histosol is found in areas constituting of peat, which includes open mires, arable land and areas covered with forest.
2) *Leptosol* is a soil type present in areas with a thin layer of regolith overlying the bedrock. This soil type is formed at sites with less than 25 cm of regolith upon the bedrock. Leptosol mainly occurs at the highest points in the landscape.
3) *Gleysol* is a soil type that is periodically saturated with water. High groundwater level and gleyic properties characterise this soil type. The properties of Gleysol are caused by changes between reducing and oxidising conditions.
4) *Podsol* is a soil type with low pH which has a subsurface, often rust coloured, called the spodic horizon. The spodic horizon is enriched in organic matter and amorphous iron oxides with or without aluminium. The spodic horizon is characterised by its dark colour. Podsol is the most common soil in Sweden and is typically found in areas with glaciofluvial sediments or till.
5) *Umbrisol* is a fertile soil type which develops on medium-textured soils and is often used as arable land. The uppermost horizon is dark and rich in organic material.
6) *Cambisol* is a soil type which is young and fertile and often develops on fine-grained sediments such as clay.
7) *Regosol* is a soil type which develops on coarse-grained material and is characterised by incomplete development of soil horizons. This is due to a short time of exposure to soil forming processes.

For a more thorough description of the characteristic of the different soil types, the reader is referred to /WRB 1998/.

3.4 Regolith depth and stratigraphy model

/Nyman et al. 2008/ have constructed a model showing the total depth and stratigraphy of the regolith in the regional model area. Data obtained from drilling, excavation and geophysical investigations were included in the model. The model is based on a conceptual understanding of QD as well as on surface and stratigraphical data on QD in the Laxemar-Simpevarp regional model area (see sections 6.2 and 6.3 below).

The program used in the modelling of QD depths is the GeoModel, a graphical tool for geological modelling and editing in a GIS environment /DHI Water & Environment 2005/. The model shows the geographical distribution of total QD depths and bedrock topography. The GeoModel can also be used for obtaining a general view of the observation points, e.g. boreholes, and permits stratigraphical profiles to be extracted. The GeoModel is closely linked to the hydrological modelling tool MIKE SHE, which is being used for the near-surface groundwater modelling /Werner et al. 2005/.

The area modelled for regolith depths (Figure 3-3) has a somewhat larger extent than the Laxemar-Simpevarp regional model area (Figure 2-1) in order to correspond to the water divider and the basins at sea. Six layers (Z1–Z6), corresponding to the most commonly occurring QD in the area (see Table 6-9 in section 6.3 below), are present in the model (Table 3-1, Figure 3-4). The uppermost layer, Z1, corresponds to the layer affected by surface processes, i.e. the soil in the terrestrial areas. The model presents the geometry of the lower level for each layer as elevation above sea level (RH 70) and with a resolution of 20 × 20 metres. The lower level of layer of Z6 corresponds to the bedrock surface. Different properties can be assigned to the six layers based on other geographical information, e.g. the QD and soil type maps.

The thickness of the QD varies considerably between the valleys with large QD depths and the higher topographical areas with thinner QD layers (see Chapter 6.3 below). Nine domains were therefore used for the depth modelling (Table 3-2). These areas were defined by the use of the QD maps from the terrestrial and marine areas. The peat areas shown on the QD map have been subdivided into two different type areas, deep and shallow. The reason for this is that the peat in some small peat areas rests directly upon till or bedrock, whereas the peat in other areas rests upon thick layers of clay (see 6.3 below). The average regolith depths in the domains were calculated using available data.

Different methods have been used in different parts of the model area for constructing the QD depth model. In Area 5 (Figure 2-2), in the marine area mapped by /Elhammer and Sandkvist 2005/, the density of data is high enough for interpolation of the QD depths (Figures 2-3 and 2-4). Fewer QD depth data are available from most of the other areas. The interpolation was therefore done with the few data available together with the calculated average depth values for the different domains (Table 3-2, Table 6-10). For a thorough description of the methods used for QD depth modelling, the reader is referred to /Nyman et al. 2008/.

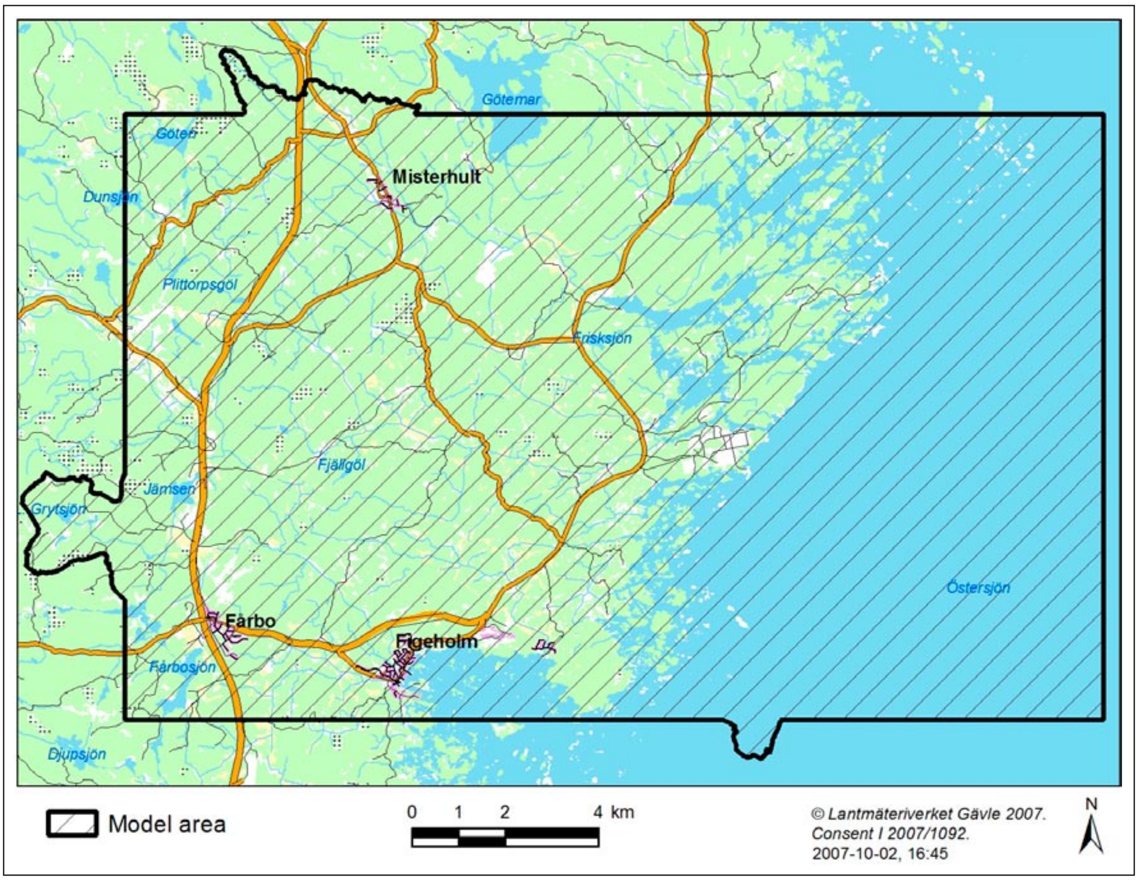


Figure 3-3. *The area covered by the regolith depth and stratigraphy model.*

Table 3-1. Description of the layers used in the QD depth model. The stratigraphical distribution of the Z-layers is shown in Figure 3-4.

Layer	Description
Z1	This layer represents the uppermost regolith and is present within the entire modelled area, except in areas covered by peat. On bedrock outcrops, the layer is set to 0.1 metre and in other areas to 0.6 metre. If the regolith depth is less than 0.6 m, Z1 will be the only layer. In the terrestrial areas, this layer is supposed to be affected by soil forming processes.
Z2	This layer is present where ***peat*** is shown on the QD map. The peat areas have been subdivided into deep and shallow peatlands (see Table 3-2).
Z3	The layer represents ***postglacial clay gyttja, gyttja*** or ***recent fluvial sediments***.
Z4	This layer represents ***postglacial coarse-grained sediments (mostly sand and gravel), artificial fill*** and ***glaciofluvial sediments***. Z4 is equivalent to artificial fill or glaciofluvial sediments in areas shown as these deposits on the QD map. In all other areas, Z4 represents the postglacial sediments. Two different average depths were used for the glaciofluvial deposits. One value for the Tuna esker and another value for the other shallower deposits. The glaciofluvial sediment and artificial fill rest directly upon the bedrock. The postglacial sand and gravel are always underlain by glacial clay (Z5) and till (Z6).
Z5	The layer represents ***glacial clay***. Z5 is often overlain by postglacial sand/gravel (Z4).
Z6	This layer represents ***glacial till***, which is the most common QD in the model area. Z6 is 0 if the total QD depth is < 0.6 metre (e.g. at bedrock outcrops) or if Z4 (see above) rests directly on the bedrock surface. The lower limit of Z6 represents the bedrock surface, i.e. Z6 represents a DEM for the bedrock surface.

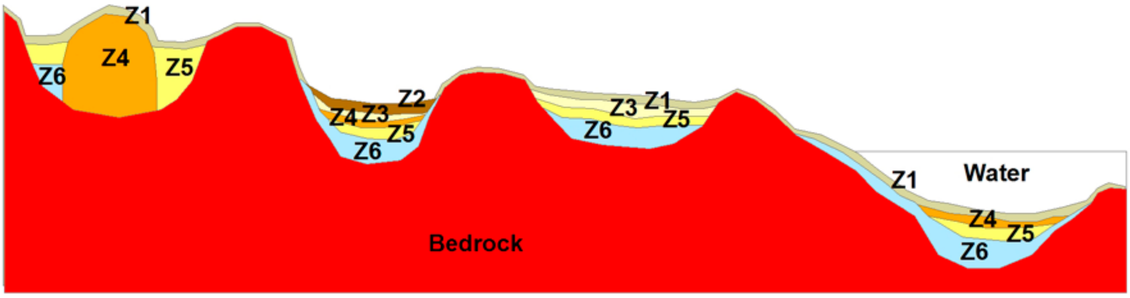


Figure 3-4. *The stratigraphical model which was used for modelling stratigraphy and total depth of QD in the Laxemar-Simpevarp regional model area. The different Z layers are explained in Table 3-1.*

Table 3-2. The different domains used for the QD depth model. The type areas are described in the conceptual QD model. The artificial fill has not been related to any of the type areas. The different Z layers used for the stratigraphy are explained in Table 3-1. The stratigraphy is further explained in Table 6-10. Areas 7 and 8 have the same stratigraphy but the thickness of Z4 is larger in domain 7. The geographical distribution of the domains is shown in Figure 6-22.

Type area	Domain	Quaternary deposit	Stratigraphy from the ground surface and downwards
I	**1**	Bedrock outcrops with no or almost no regolith coverage	Z1/bedrock
I	**2**	Till, shingle and boulders	Z1/Z6/bedrock
II	**3**	Clay gyttja, gyttja and recent fluvial sediments	Z1/Z3/Z4/Z5/Z6/bedrock
I	**4**	Peat, shallow. (Peat areas that not border on areas with clay or postglacial sand/gravel and are forested or clear-cut)	Z2/Z6/bedrock
II	**5**	Peat, deep	Z2/Z3/Z4/Z5/Z6/bedrock
II	**6**	Glacial clay and postglacial sand/gravel	Z1/Z4/Z5/Z6/bedrock
III	**7**	Glaciofluvial deposits, deep	Z1/Z4/bedrock
III	**8**	Glaciofluvial deposits, shallow	Z1/Z4/bedrock
	9	Artificial fill	Z1/Z4/bedrock

4 Quaternary development of the Laxemar-Simpevarp area

This chapter gives a review of the Quaternary development of the Laxemar-Simpevarp area. For a more thorough historical description, the reader is referred to /Söderbäck 2008/ and /SKB 2006b/. Most of the results presented in this chapter come from studies that have been conducted outside the Laxemar-Simpevarp regional model area. For a thorough description of the Quaternary development of the Laxemar-Simpevarp area, the reader is referred to /Söderbäck 2008/.

The Quaternary is the present geological period, which started 2.6 million years ago. It is characterised by a considerably colder climate than the previous period, called the Tertiary. The Quaternary climate is also characterised by large, sometimes fast, changes of global temperature. One effect of the large climate variation is the waxing and waning of large ice caps. Sweden is one area that repeatedly has been covered by ice sheets, something, which has had a large impact on the distribution of the regolith and the morphology of the landscape. This in turn has affected the near surface hydrology and the local distribution of soils and vegetation /e.g. Berglund et al. 1996/.

The interpretation of the Quaternary development is of fundamental importance when explaining the distribution of the regolith deposits in Sweden and other areas that have been glaciated. Past variations in climate, vegetation etc affect the properties of sediments that accumulate on the floors of lakes and sea. Moreover the properties of the soils are an effect of the past environment. The distribution of different soil types can therefore provide information about both past environmental conditions and past land use.

A combination of climatic oscillations of high amplitude, together with the intensity of the colder periods /e.g. Shackleton et al. 1990/, is characteristic of the Quaternary Period. In Sweden, and in other areas situated at high and low latitudes, the climate has alternated between cold glacial and warm interglacial stages. The glacial stages are further subdivided into cold phases, stadials, and relatively warm phases, interstadials. The Quaternary Period is subdivided into two epochs: the Pleistocene and the Holocene. The latter represents the present interglacial, which began c 9500 years BC.

Results from studies of sediments from the world oceans suggest numerous glaciations during the Quaternary Period /e.g. Shackleton et al. 1990/. The absolute number of ice sheets covering the Laxemar-Simpevarp area is, however, unknown. End moraines from three glaciations are known from northern Poland and Germany /e.g. Andersen and Borns 1997/. It can therefore be concluded that the Laxemar-Simpevarp area has been glaciated at least three times, but probably more, during the Quaternary Period.

The latest glacial, the Weichselian started c 115,000 years ago. It was characterised by colder phases, stadials, interrupted by milder interstadials. Numerous sites with interstadial deposits from the early part of Weichsel are known from the interior of northern Sweden /Lagerbäck and Robertsson 1988/. Several authors have suggested that most of Fennoscandia was free of ice during these early Weichselian interstadials /e.g. Lundqvist 1992/. The northern parts of Fennoscandia were probably covered by ice during the Early Weichselian stadials. It has been generally believed that a large part of Fennoscandia was covered with ice from the beginning of the Mid-Weichselian (70,000 years ago) until the latest deglaciation. The models presented by e.g. /Lundqvist 1992/ and /Fredén 2002/ is often used to illustrate the evolution of the Weichselian (Figure 4-1). However, the exact timing of the Mid-Weichselian glaciation is unknown and there are indications of ice-free condition in large parts of Fennoscandia during parts of the Mid-Weichselian /e.g. Ukkonen et al. 1999, Lokrantz and Sohlenius 2006/. The Laxemar-Simpevarp area was probably free of ice during the Early Weichselian stadials and interstadials (Figure 4-1). It has been assumed that tundra conditions prevailed during the stadials /Fredén 2002/. The vegetation during the first Weichselian interstadial was probably dominated by coniferous forest, whereas the second interstadial was colder, with the forest sparse and dominated by *Betula* (Birch). The ice advanced south and covered the Laxemar-Simpevarp area first during the Mid-Weichselian (c 70,000 years ago). Since large parts of Sweden may have been free of ice during parts of the Mid-Weichselian, the total duration of ice coverage in the Laxemar-Simpevarp area may have been considerably shorter than implied in (Figure 4-1). According to a reconstruction of the Weichselian ice sheet by ice sheet modelling, the maximum thickness of the ice cover in the Oskarshamn region was about 2.4 km during the Last Glacial Maximum 160,000 BC /SKB 2006b/.

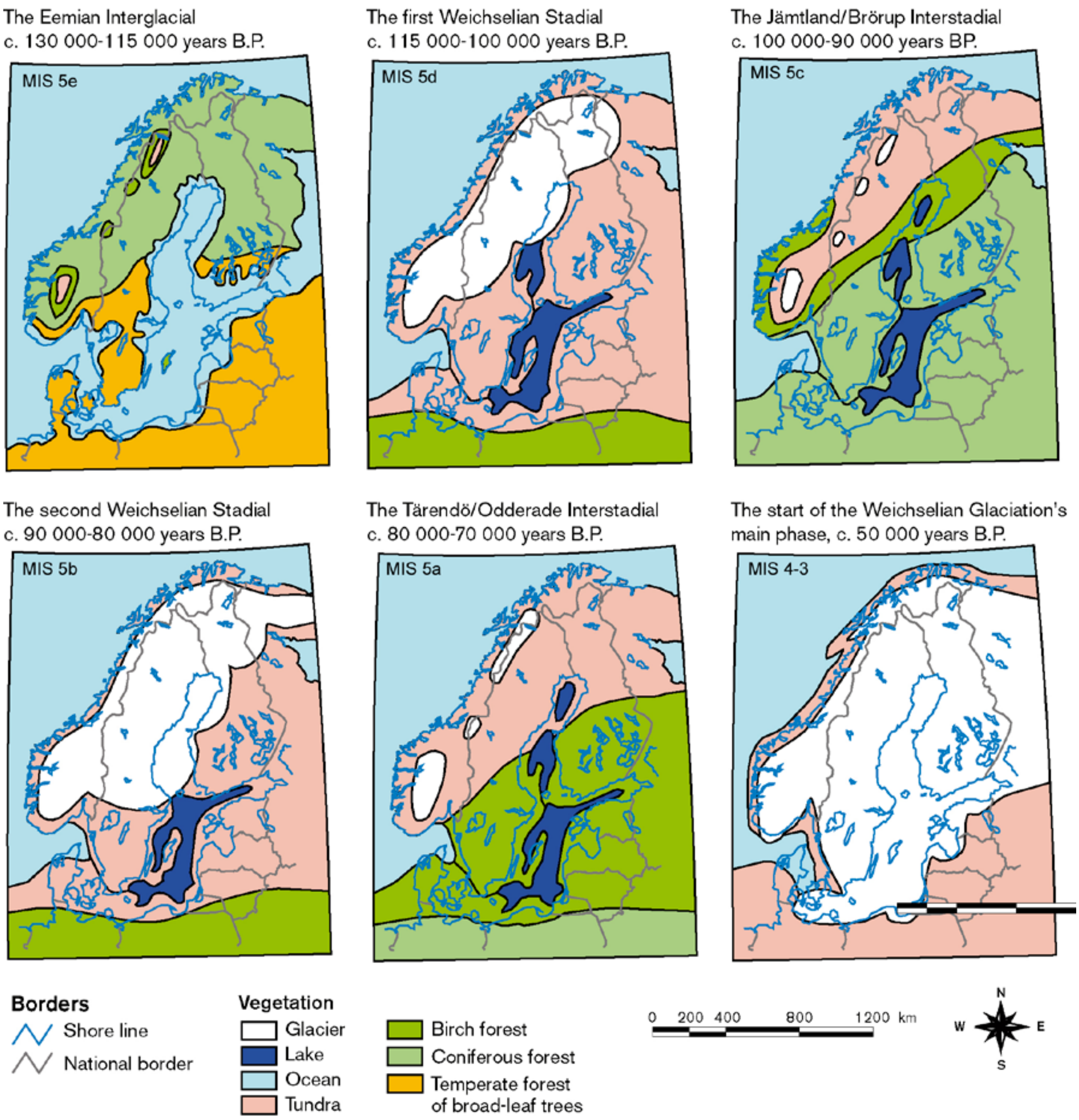


Figure 4-1. Changes in the vegetation and ice cover in northern Europe during the latest interglacial (Eem) and first half of the last ice age (Weichselian). The different periods have been correlated with the Major Isotope Stages (MIS). The maps should be regarded as hypothetical due to the lack of well dated deposits from the different stages /from Fredén 2002/.

The occurrence of regolith older than the latest glaciation may indicate low erosion during the latest glaciation. There are indications of QD deposited before the latest glaciation in eastern Småland. The possibility can therefore not be excluded that QD older than the last Weichselian glacial phase also exist in the Laxemar-Simpevarp area. Older glacial till and fluvial sediments of unknown age were discovered during SGU's mapping of QD in Västervik, c 40 km north of Laxemar /Svantesson 1999/. Till-covered water-laid deposits on the south Swedish Highland have been described by /Rydström 1971, Jönsson 1979, Daniel 1989/. /Rydström 1971/ suggests that these water-laid deposits were deposited during a Weichselian interstadial.

/Lagerbäck et al. 2004, 2005ab, 2006/ searched for traces of possible late or postglacial faulting in the Oskarshamn region. The results were also used to discuss the age and stratigraphy of QD in the area. The study includes results from stratigraphical descriptions made in machine-cut trenches. The machine-cut trenches were all situated close to glaciofluvial eskers, and at several sites a diamicton (i.e. unsorted material with large variation in particle size) covering the glacial clay was recorded. It is suggested that the diamicton may be glacial till. The till was probably deposited during the latest glacial phase. The underlying glacial clay and glaciofluvial sediments may consequently have been deposited during a deglaciation older than the latest deglaciation.

One of the machine-cut trenches studied by /Lagerbäck et al. 2005a/ was situated close to the Tuna esker, close to Fårbo, in the western part of the Laxemar-Simpevarp regional model area. The stratigraphical results suggest that the Tuna esker and the surrounding sediments were deposited during the latest glaciation.

In the Laxemar-Simpevarp regional model area, there is no evidence of QD's that were deposited before the last phase of the Weichselian glaciation. The stratigraphical distribution of QD (Table 6-9) shows the succession that can be expected in an area where the deposits were formed from the latest ice age and onwards. The results from drilling and excavation in the Laxemar-Simpevarp area presented below do not indicate the occurrence of any such "old" deposits /Sohlenius et al. 2006a, Morosini et al. 2007/. However, the widespread occurrences of deposits that may have been deposited before the last phase of the Weichselian glaciation suggest that such deposits may also occur in the Laxemar-Simpevarp regional model area. Furthermore, several sites with deep weathered bedrock of Pre-Quaternary age are known to exist in the inland of Småland, the closest c 50 km west of the Laxemar-Simpevarp regional model area /Lidmar-Bergström et al. 1997/. These deposits indicate that the intensity of glacial erosion has been low in the areas west of the Laxemar-Simpevarp area.

The directions of glacial striae and results from three clast fabric analyses of three till samples are used to reconstruct the direction of ice movements during the latest ice age. These studies can theoretically also provide information about ice movement directions during older glaciations. Glacial striae on bedrock outcrops indicate a youngest ice movement from N30°W–N45°W and N40°W–N60°W in the Västervik and Oskarshamn areas, respectively /Svantesson 1999, Rudmark 2000/. In the Laxemar-Simpevarp area as well, most striae observations indicate that the latest active ice sheet moved from the northwest. One fabric analysis and two striae observations indicate a relatively old direction of ice movement from the northeast /Rudmark et al. 2005, Sohlenius et al. 2006a/. It is therefore suggested that an ice sheet moving from the northwest followed the ice moving from the northeast.

The Oskarshamn area was deglaciated almost 12,000 years BC /Lundqvist and Wohlfarth 2001/. The ice front had a northeast-southwest direction during the deglaciation, which is perpendicular to the latest ice movement (see above).

The development of the Baltic Sea since the last deglaciation is characterised by changes in salinity (Figure 4-3) caused by variations in the relative sea level. This history has therefore been divided into four main stages /Björck 1995, Fredén 2002/, which are summarised in Table 4-1 and Figure 4-2. Freshwater conditions prevailed during most of the deglaciation of Sweden. Brackish conditions prevailed 9300–9100 years BC during the Yoldia Sea stage /e.g. Andrén et al. 2000/. The salinity was between 10‰ and 15‰ in the central Yoldia Sea /Schoning et al. 2001/. That stage was followed by the Ancylus Lake, which was characterised by freshwater conditions until the onset of the Littorina Sea around 7500 years BC /Fredén 2002, Berglund et al. 2005/.

Table 4-1. The four main stages undergone by the Baltic Sea since the latest deglaciation. The Littorina Sea here includes the entire period from the first influences of brackish water at 7,500 years BC to the present Baltic Sea.

Baltic stage	Calendar years BC	Salinity
Baltic Ice Lake	13,000–9500	Glacio-lacustrine
Yoldia Sea	9500–8800	Lacustrine/Brackish /Lacustrine
Ancylus Lake	8800–7500	Lacustrine
Littorina Sea *(Sensu lato)*	7500–present	Brackish

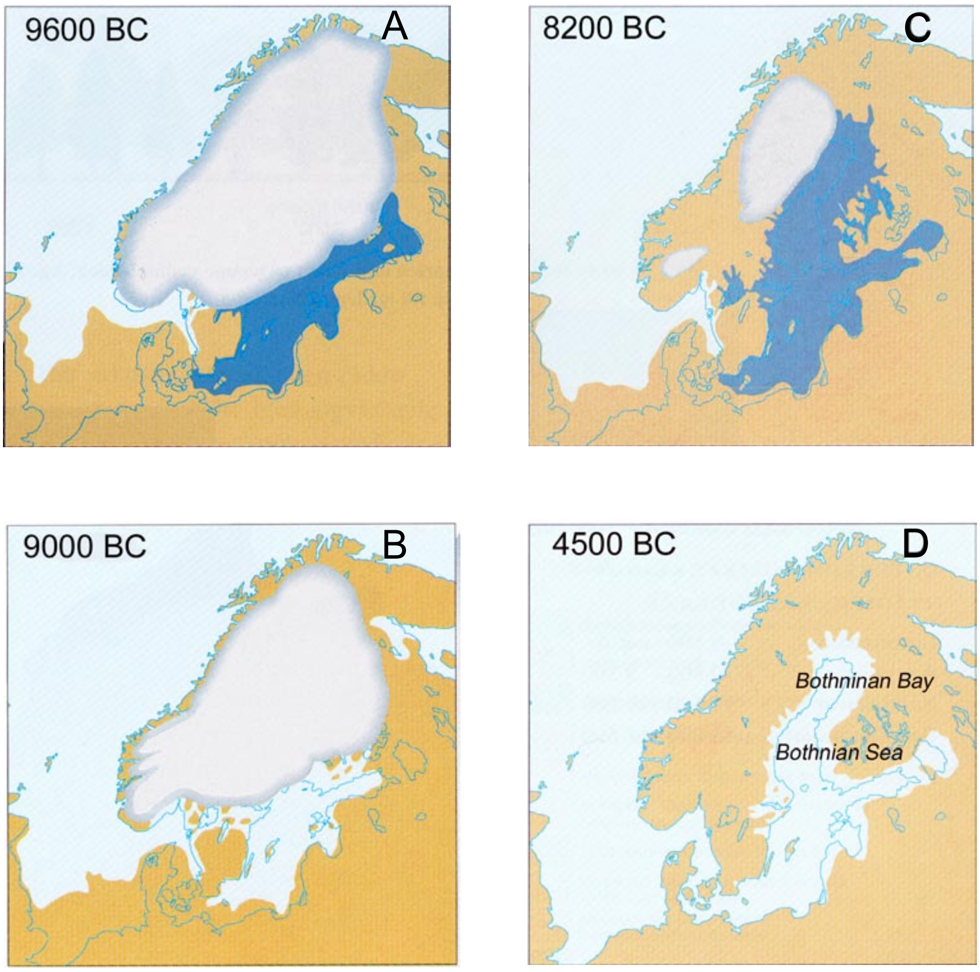


Figure 4-2. *Four main stages characterise the development of the Baltic Sea since the latest deglaciation: A) the Baltic Ice Lake (13,000–9,500 BC), B) the Yoldia Sea (9,500–8,800 BC), C) the Ancylus Lake (8,800–7,500 BC) and D) the Littorina Sea (7,500 BC-present). Fresh water is symbolised by dark blue and marine/brackish water by light blue /from Fredén 2002/.*

Salinity was probably low during the first c 1000 years of the Littorina Sea stage but started to increase 6500 years BC. Salinity variations since the onset of the Littorina Sea have been summarised by /Westman et al. 1999/ and are shown in Figure 4-3. The most saline period occurred 4000–3000 years BC, when the surface water salinity in the Baltic proper (south of Åland) was 10–15‰ compared with approximately 7‰ today /Westman et al. 1999/. However, since the Laxemar-Simpevarp area has been situated close to the coast during most of the Littorina stage, it can be assumed that salinity has been generally lower than is shown in Figure 4-3.

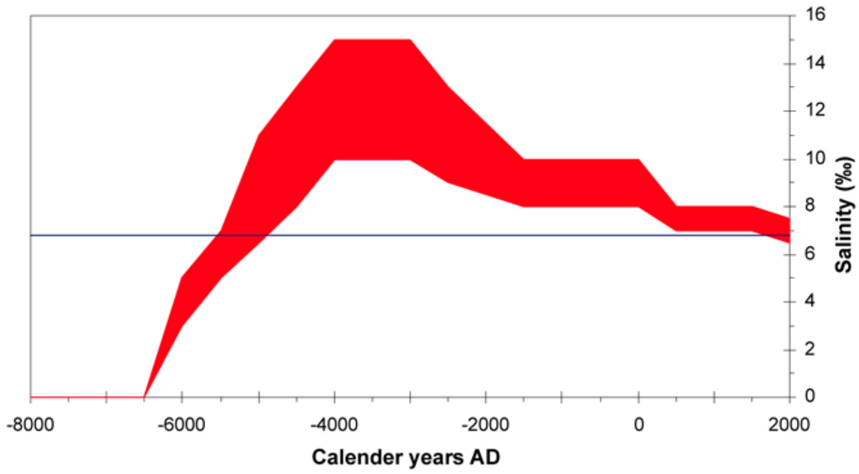


Figure 4-3. *Salinity variations in the open Baltic proper outside Laxemar-Simpevarp during the last 10,000 years /from Westman et al. 1999/.*

The highest shoreline in the Oskarshamn region is c 100 metre above sea level /Agrell 1976/, which means that the whole Laxemar-Simpevarp regional model area is situated below the highest shoreline. Land uplift was fastest (c 2 cm/year) during the first few thousand years following the deglaciation /Påsse and Andersson 2005/. In the Laxemar-Simpevarp region, shoreline regression has prevailed and the rate of land uplift during the last 100 years has been c 1 mm/year /Ekman 1996/.

The late Weichselian and early Holocene shoreline displacement in the Oskarshamn region has been studied using stratigraphical methods by /Svensson 1989/. The estimated shoreline displacement since the last deglaciation has been reviewed and modified by /Påsse 1997, 2001, Påsse and Andersson 2005/ (Figure 4-4). According to /Svensson 1989/ and several other authors /e.g. Björck 1995/ shoreline dropped instantaneously c 25 metres due to drainage of the Baltic Ice Lake 9500 years BC. Påsse suggests, however, that a fast isostatic component and not a sudden drainage caused the fast shoreline displacement at the end of the Baltic Ice Lake. The drainage was followed by the Yoldia Sea stage, which was dominated by freshwater conditions, but was influenced by brackish water for about 100–150 years. The onset of the following Ancylus Lake stage was characterised by a transgression of c 11 metre. There are no studies from the Oskarshamn area dealing with shoreline displacement during the Littorina Sea stage. Results from a study c 100 km north of Laxemar /Robertsson 1997/ suggest a regressive shoreline displacement during the Littorina stage. However, more detailed stratigraphical studies of sediments from areas north (Södermanland) and south (Blekinge) of the Laxemar-Simpevarp area have shown that three (Södermanland) and six (Blekinge) transgressions occurred during that period /Berglund 1971, Risberg et al. 1991/. It is therefore likely that several transgressions occurred in the model area during the Littorina stage. The shoreline displacement curve presented by /Påsse and Andersson 2005/ shows one transgressive phase during the early part of the Littorina Sea but does not reveal any other transgressive phases.

/Berglund et al. 1996/ reviewed data concerning the development of the vegetation in Sweden after the latest deglaciation. There are no pollen stratigraphical investigations from the Laxemar-Simpevarp area or neighbouring areas that reveal the development of the vegetation development after the latest deglaciation. Pollen stratigraphical investigations from Blekinge show the succession of terrestrial plants in southeastern Sweden from the latest deglaciation to the present /Berglund 1966/. After the deglaciation in 12,000 years BC, the Laxemar-Simpevarp area was probably characterised by tundra vegetation dominated by herbs and bushes and a low coverage of trees. That was followed by a period when a sparse *Pinus* (pine) and *Betula* (birch) forest dominated the vegetation. The following cold Younger Dryas chronozone (c 11,000–9500 years BC) was characterised by tundra vegetation reflected by a high proportion of *Artemisia* (wormwood) pollen. At the beginning of the Holocene c 9500 years BC, the temperature increased and southeastern Sweden was first covered by forests dominated by *Betula* and later by forests dominated by *Pinus* and *Corylus* (hazel).

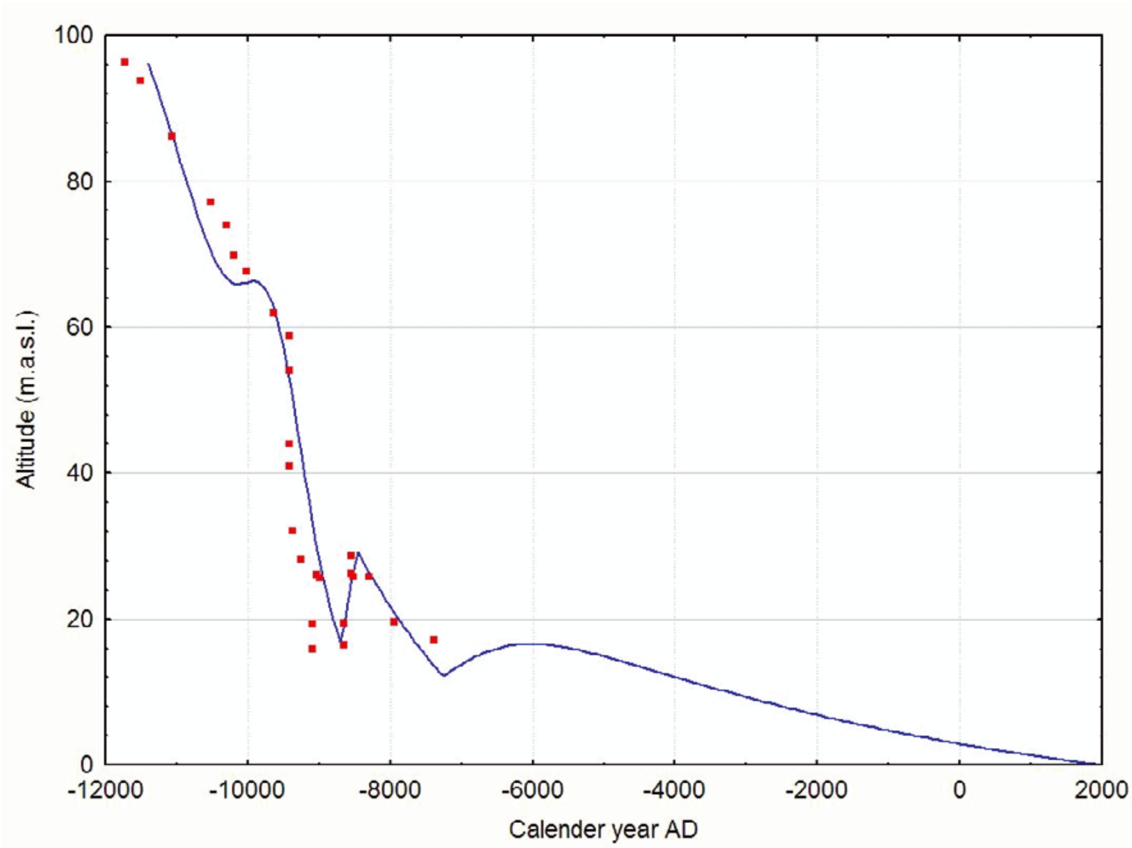


Figure 4-4. *Shoreline displacement in the Oskarshamn area after the latest deglaciation. The blue symbols show a curve established by /Svensson 1989/ after a study of lake sediments in the region. The curve without symbols has been calculated using a mathematical model /Påsse 2001/.*

7000–4000 years BC a forests dominated by *Tilia* (lime), *Quercus* (oak) and *Ulmus* (elm) covered southeastern Sweden. The summer temperature in southern Sweden was approximately 2°C warmer than at present /Antonsson and Sepää 2007/. The temperature decreased following this warm period, and the forest has gradually become increasingly dominated by coniferous trees. Spruce spread from the north and reached the Laxemar-Simpevarp area less than 1000 years AD /Lindbladh 2004/.

A pollen investigation covering the last c 1500 years has been carried out on sediments from two lakes situated 20 and 25 kilometres west of Fårbo /Aronsson and Persson, unpublished data/. The results show an increase of *Juniperus* (juniper) and *Cerealea* (corn) c 800 AD, which indicates that areas used as arable land and for pasture increased during that time.

The historical land-use in the Laxemar-Simpevarp area has been reviewed by /Berg et al. 2006/. In the Laxemar-Simpevarp area there was an increase in the areas used as arable land and meadows during the 18th and 19th centuries. The last century has been characterised by a decrease in the areas used as meadows and arable land, especially since the Second World War.

The groundwater level in many wetlands was lowered by ditches during the early to mid 20th century /Nyborg et al. 2004/. Several lakes were also lowered during that period, e.g. the former Lake Gästern.

5 Methods and data evaluation

The methods used to map and determine the properties of soils and Quaternary deposits (i.e. regolith) are described briefly in the following text. The section also includes evaluation of the data used in the models of the regolith.

5.1 Surface distribution of soils and Quaternary deposits

The QD map shows the distribution of QD at a depth of 50 cm in the whole Laxemar-Simpevarp regional model area. Some of the surface layers thinner than 50 cm were also marked on the map (e.g. peat overlaying other deposits). The geographical distribution of QD was used together with other data to produce a soil type map covering the whole of the Laxemar-Simpevarp regional model area.

5.1.1 The terrestrial part of the model area

The distribution of QD in the Laxemar-Simpevarp area with surroundings has earlier been mapped by SGU /Svedmark 1904/. It was not possible to use that map in the SKB site investigation, since its geographical accuracy was too low. The distribution of QD in the terrestrial part of the Laxemar-Simpevarp regional model area was mapped by /Rudmark et al. 2005/. Different methods were used for mapping of QD (Figure 2-2). First, the distribution of QD in the whole terrestrial part of the model area was interpreted in aerial photos. In the following field checks the uppermost deposits were investigated using a spade and a hand driven probe. In the Laxemar and Simpevarp subareas, QD were mapped for presentation on a scale of 1:10,000 (Area 1 in Figure 2-2). This means that the part of the map that includes the two subareas shows all identified bedrock exposures and QD with a surface extent exceeding 10 by 10 metres. The remaining parts of the River Laxemarån drainage area and the glaciofluvial deposit, Tunaåsen, were mapped for presentation on a scale of 1:50,000 (Area 2 in Figure 2-2). The smallest marked area is in general about 40 by 40 metres. However, small observed bedrock outcrops have been symbolised with crosses. The same principle of classification has been used in the two areas. The area mapped using the two methods described above is referred to as the local area in the following text (Areas 1 and 2 in Figure 2-2).

Remaining terrestrial parts of the Laxemar-Simpevarp regional model area was also mapped for presentation on a scale of 1:50,000 (Area 3 in Figure 2-2). The distribution of QD on this part of the map was, however, to a large extent interpreted from aerial photos. These interpretations were field-checked along the road network. A more generalised method of classification was used in this area. It was not possible to access the areas around the village Värnamo (Area 4 in Figure 2-2). The distribution of QD in that area was therefore entirely interpreted from aerial photos. Bedrock outcrops are often easily distinguished in the interpretation of aerial photos. Peat and fine-grained deposits, such as clay or sand, are more difficult to detect in areas covered by forest. Areas with such deposits may consequently be missing on the parts of the map based on interpretations of aerial photos. It was not possible to distinguish areas with glacial clay from areas with postglacial clay gyttja in the interpretation of aerial photos. In areas interpreted from aerial photos (Areas 3 and 4), all clays are therefore symbolised with the same colour.

During the fieldwork in Areas 1 and 2, the information from interpretation of aerial photos was checked. New and correct boundaries showing exposed bedrock and the distribution of different QD at a depth of 0.5 metre were drawn on the aerial photos. However the till often has a high frequency of boulders and stones and it was therefore difficult to check if the till layers overlying the bedrock exceed 0.5 metre. It is consequently likely that some of the areas mapped as till have a total regolith thickness of less than 0.5 metre. Most areas mapped as bedrock outcrops lack a soil layer or are covered with a thin vegetation layer, e.g. roots, mosses and lichens. Thin layers (< 0.5 metre) of predominantly till or peat may, however, occasionally occur in the areas shown as bedrock outcrops on the QD map.

Peat areas with a thickness less than 0.5 metre were marked in the field and are shown on the QD map (e.g. peat overlaying clay gyttja).

During the mapping of QD, directions of glacial striae were observed and measured at about 130 localities. The results are discussed in the chapter dealing with the Quaternary development (Chapter 4) and in /Söderbäck 2008/.

The distribution of QD on the floors of lakes and ponds has been interpreted by Sohlenius (SGU) after evaluating the results from sediment cores and after comparison with the terrestrial map of QD (Area 11 in Figure 2-2). That interpretation has not been presented in any report.

5.1.2 The marine areas

The stratigraphical and geographical distribution of QD on the sea floor of in the Laxemar-Simpevarp regional model area was to a large extent mapped by /Elhammer and Sandkvist 2005/. A significant part of the coastal area and archipelago was mapped by /Ingvarson et al. 2004/. Granholmsfjärden was mapped both by /Ingvarson et al. 2004/ and /Elhammer and Sandkvist 2005/ (Area 7 in Figure 2-2). A large part of the regional model area was, however, not included in the marine geological mapping programme. Some of these areas have been mapped within SGU's regular marine geological mapping program (Area 8 in Figure 2-2).

In the area close to the Simpevarp peninsula and the island of Ävrö, /Elhammer and Sandkvist 2005/ used a vessel to collect data in profiles with a spacing of 100 metres (Area 5 in Figure 2-2). This area is referred to as the detailed area. Further out in the regional Laxemar-Simpevarp area, a spacing of 1 km was used (Area 6 in Figure 2-2). This part of the mapped area is referred to as the local area. Surveying in areas with water deeper than 6 metres was performed from S/V Ocean Surveyor, while a smaller vessel was used at water depths between 3 and 6 metres. The survey includes echo sounding, sediment echo sounding, seismic reflection and side scan sonar. Samples were taken to verify the interpretation from the acoustic measurements. Soft bottoms (clay) were sampled with a core and coarser deposits with a grab sampler. The results were used to produce maps showing the distribution and total depths of QD. The distribution of QD is mapped from a depth from approximately 0.5 metre below the regolith-water interface. Thin surface layers of e.g. sand were also mapped in the SGU survey. The surface frequency of boulders at the sea floor was recorded in the detailed area (Area 5 in Figure 2-2).

/Ingvarson et al. 2004/ mapped the distribution of QD in parts of the coastal area and archipelago. In areas with a water depth exceeding 3 metres, a fully equipped survey vessel was used. A smaller vessel was used to survey the shallowest areas. An offset of 80 metres was used in the survey with the large vessel. The stratigraphy and geographical distribution of QD on the sea floor were investigated with multi beam echo sounder side scan sonar and shallow seismic. The results were used to produce a map covering large parts of the coastal areas and archipelago (Area 9 in Figure 2-2). That map shows the distribution of QD on the surface of the sea floor, whereas the map by SGU shows the distribution of QD at a depth of 0.5 meter below the sea floor. /Ingvarson et al. 2004/ took no samples to verify their interpretations of QD.

The marine geological data have been used within the earlier SurfaceNet modelling work /Lindborg 2006/. It was then noted that there are significant deviations between the map produced by /Ingvarson et al. 2004/ and the map /from Elhammer and Sandkvist 2005/. The QD data from the sea floor were therefore re-interpreted by /Kjellin 2007/. The results were used to produce a map showing the distribution of QD at a depth of 0.5 metre below the sea floor. That map covers both the areas mapped by /Ingvarson et al. 2004/ and the areas mapped by /Elhammer and Sandkvist 2005/. The map also shows the distribution of thin layers of gravel and sand in the areas mapped by /Ingvarson et al. 2004/.

/Kjellin 2007/ also made an interpretation that shows the supposed distribution of QD in the areas that were not included in the marine geological mapping programme (Area 10 in Figure 2-2). That interpretation was based on the known distribution of QD in the mapped marine and terrestrial areas. He also used bathymetric information from the charts produced by the Swedish Maritime Administration. The interpretation by Kjellin should not be regarded as an ordinary QD map, but more as a general view of the likely composition of the regolith cover.

The bay of Borholmsfjärden (Figure 2-1) was not included in the regular marine geological programme. /Kenczek and Sunesson 2006/ mapped the floor of Borholmsfjärden and made a map showing the distribution of soft and hard bottoms. Areas mapped as soft bottoms are supposed to represent areas with postglacial clay (clay gyttja). In Borholmsfjärden, the interpretation in Area 10 by Kjellin consequently has a higher reliability.

5.1.3 Soils

Soils from 10 different land classes were studied within the Laxemar-Simpevarp regional model area /Lundin et al. 2004, Lundin et al. 2005/. The land classes (Table 5-1) were defined based on vegetation, land use, and wetness. Classifications of soil types and QD were carried out in eight spade-dug profiles at two sites from each land class.

The aim of the soil classification was to define soils with special properties, which were then compared with soils from other areas of Sweden. The soils were classified according to /WRB 1998/. The 2-3 uppermost soil horizons were sampled and analysed for pH, organic carbon, nitrogen and calcium carbonate.

The properties of the QD have a great influence on the soil forming processes. The QD maps /Rudmark et al. 2005/ were therefore used together with other information, such as land use, distance to the sea and vegetation maps (tree, field and ground layer) /Boresjö Bronge and Wester 2003/, to interpret the geographical distribution of soils in the model area. The wetness of the soil is to a large extent dependent on the topographical location of a site. Wetness is of considerable importance for the soil forming processes. /Lundin et al. 2005/ calculated the topographical wetness index (TWI) from the DEM /Beven and Kirkby 1979/. The index describes the spatial distribution of the groundwater table, and was further used during the classification of soils in the model area. The main soil types recognised in the investigated area are shown in Table 5-1. Maps of organic carbon, nitrogen and pH in the different soil horizons were produced based on the soil type map and the soil chemical data from the investigated sites.

Table 5-1. The soil types and abbreviations used on the soil-type map. The definitions of these soil types are described in Chapter 3.3.

Soil type	Abbreviation	Land class
Leptosol	LP	Small rock outcrops and thin soils, mostly coniferous forest
Podsol/Regosol	PZ/RG	Till, mostly coniferous forest
Podsol/Regosol (on glaciofluvial sediments)	PZ/RG-e	Glaciofluvial deposit (esker), mostly coniferous forest
Umbrisol-Regosol	UM/RG	Mostly till, deciduous forest
Umbrisol-Gleysol	UM/GL	Meadows
Histosol	HI-d	Drained peat soils covered by forest
Histosol	HI-w	Peat soil, open wetland
Histosol	HI-a	Peat soil used as arable land
Histosol (small peatlands)	HI-s	Peat soil in small wetlands surrounded by exposed bedrock
Regosol/Histosol (shoreline areas)	RG/HI	Shore
Umbrisol /Gleysol, arable land	UM/GL-a	Sediment soils used as arable land

The previous soil type map /Lundin et al. 2005/ was recently updated /Lindborg 2006/. This was done by re-interpretation of the data shown on the QD map /Rudmark et al. 2005/. Some changes have consequently been made in the original soil type map class definition presented by /Lundin et al. 2005/. The new definition especially includes thin soils and bedrock, which previously underestimated the amount of exposed bedrock and thin soils in relation to thicker soil deposits. The new definition includes one class (Bedrock) for bedrock outcrops and another class (Leptosol) for small bedrock outcrops alternating with thin soils. The scheme used for classification of soils shown on the soil type map is shown in Figure 5-1. The class names are in accordance with the Soil Classification /WRB 1998/, although they often embrace two WRB classes, in order to describe the special conditions in the area.

Since the most detailed QD maps cover the Laxemar River drainage area (Areas 1 and 2 in Figure 2-2), the reliability of the soil type map is higher in that area compared to remaining parts of the regional model area (Areas 3 and 4 in Figure 2-2).

5.2 Information about stratigraphy

5.2.1 Drilling and excavation

Data on the stratigraphy and total depth of the regolith have been obtained from a number of different investigations (Figure 2-3). The results of these investigations have been used together with the QD map to produce a model showing the stratigraphy and total depths of regolith in the whole Laxemar-Simpevarp regional model area /Nyman et al. 2008/. The regolith depths refer to the depths of the regolith from the ground surface down to the bedrock surface.

Soil/rock drilling /e.g. Johansson and Adestam 2004ab, Sohlenius et al. 2006a, Morosini et al. 2007/ provides information on the stratigraphy and total depth of QD. Weight soundings and auger drilling were done in transects across depressions to collect information regarding the spatial variations of the stratigraphy of the uppermost metres of the regolith. During the auger drilling, samples of regolith were characterised in the field. Certain samples were taken for further analysis of grain size distribution. The weight soundings give information about the physical properties of the deposits. These properties were used to identify different types of regolith. At some of the drilled sites, groundwater monitoring wells have been installed. Most of these installations do not provide information on the total thickness of the regolith, but results from the drilling can be used to interpret the stratigraphy of the uppermost, often soft, regolith (e.g. sand, silt and clay).

A spade and two different hand-driven probes were used for direct observations of the different QD (altogether 250 observations) during the mapping in the terrestrial areas /Rudmark et al. 2005/. Most of these holes do not exceed a depth of more than 2 metres below the ground surface. It is consequently not possible to use these data to estimate the total thickness of QD.

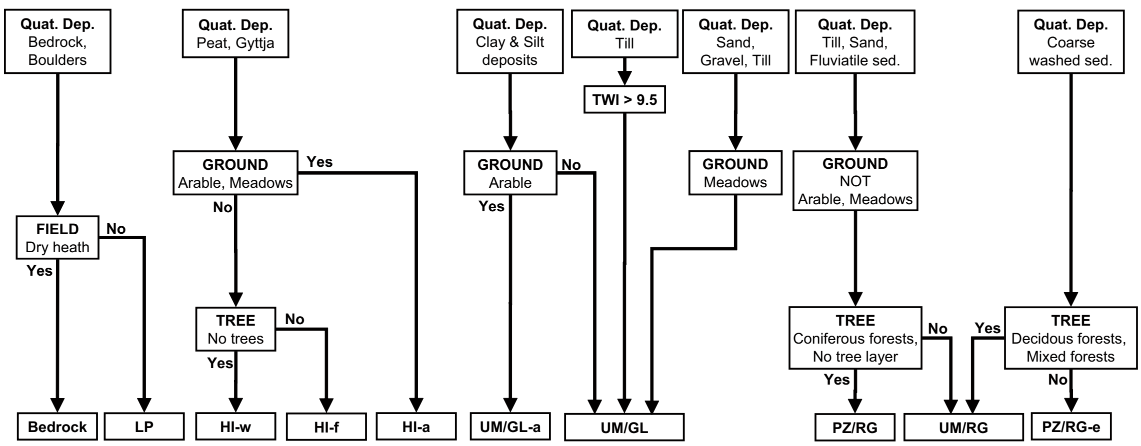


Figure 5-1. *Classification scheme of the map soil types based on maps of quaternary deposits, vegetation, and topographical index.*

The thickness and stratigraphical distribution of peat and water-laid fine-grained sediments in shallow bays, wetlands and lakes in the Laxemar-Simpevarp regional model area was investigated by /Nilsson 2004/. The sediments were sampled with a hand operated Russian peat corer. The surface sediments were further sampled with a Willner gravity corer and an Ekman dredge. Some samples retrieved with the piston corer were later used for analyses of grain size distribution, geochemistry and radiocarbon datings. The latter were done to determine the rate of sediment accumulation.

The stratigraphical distribution of sediments from the marine areas was described in four cores sampled with a six metre piston corer /Elhammer and Sandkvist 2005/. Samples from two of these cores were later used for biostratigraphical studies and radiocarbon dating /Kaislahti Tillman and Risberg 2006/.

Stratigraphical information about peat and fine-grained deposits from 19 sites in wetlands were also collected before the onset of the site investigations /Laaksoharju and Gurban 2007/. That investigation was carried out to investigate possible interactions between deep groundwater and the biosphere. There are several other previous investigations from bays and wetlands that describe the same general stratigraphical distribution of water laid sediments as reported in the present report /Borg and Paabo 1984, Landström et al. 1994, Aggeryd et al. 1996, Risberg 2002/.

In the terrestrial area the stratigraphy was determined in 25 machine-cut trenches at localities with relatively thick regolith layers /Bergman et al. 2005, Rudmark et al. 2005, Sohlenius et al. 2006a/. These studies include description of bed geometry, sedimentary and deformational structures, lithology, sorting, particle roundness, colour etc. In order to determine from what direction the till was deposited, fabric analyses were made at three of these localities. Four of the machine-cut trenches were made in the topographical lineaments, i.e. valleys, in order to establish the stratigraphy of the lowest topographical areas /Sohlenius et al. 2006a/. These areas are of special interest as they act as discharge areas for groundwater. The soils were characterised in these four trenches. Some of the machine-cut trenches reached the bedrock, which then was described. Many samples were taken during the survey of the trenches for analyses of physical and chemical properties.

5.2.2 Geophysical measurement

The geophysical surveys include both seismic and resistivity measurements. In the terrestrial areas the geophysical measurements were mainly used to estimate the total depth of QD (Figures 2-3 and 2-4).

The results from the reflection seismic survey in the marine areas /Elhammer and Sandkvist 2005/ were used to calculate the stratigraphy and thickness of till, glacial clay, postglacial sand and clay gyttja (data from almost 140,000 points). These results were also used to estimate the total thickness of QD. However, the postglacial clay often contains gas, which obstructs penetration with the seismic method. It has therefore not been possible to determine the stratigraphy and total depth of QD in many areas with postglacial sediments. These sediments commonly occur in the narrow bays that are characteristic of the archipelago in the model area.

A sediment echo sounder was used in parts of the coastal areas and archipelago /Ingvarson et al. 2004/. It was not possible to penetrate the till or hard sediments (e.g. gravel) with the sediment echo sounder. The results from that investigation could therefore not be used to determine the stratigraphy and thickness of the QD.

Refraction seismic measurements were mainly carried out in terrestrial areas with a low frequency of bedrock outcrops /Lindqvist 2004abc, 2005, 2006, 2007/. The measurements were made along transects of which several cross the pronounced valleys that characterise the model area (Figure 2-3). The results provide information on the total depth of the regolith. These results were used to determine the locations of some of the machine-cut trenches that were used for studies of the QD and underlying bedrock.

A helicopter-borne geophysical survey was carried out in 2002 /Triumf et al. 2003/ covering large parts of the Laxemar-Simpevarp regional model area. The survey included electromagnetic measurements that were carried out along lines with a separation of c 50 metre. The survey did not include the large glaciofluvial esker (the Tuna esker) in the western part of the regional model area. Electromagnetic (EM) data from the survey provided information about the electrical properties of the regolith and the bedrock. The penetration depth of the EM method is between 30 and 200 metres. Vertical electrical soundings (VES) were carried out on the ground to obtain information on the electrical resistivity of the different QD in the area /Thunehed and Pitkänen 2003, Thunehed 2006/. The results from the VES survey were also used to calculate the total depth of the regolith.

Electrical resistivity was measured along transects on the ground in selected areas within the Laxemar subarea (Figure 2-1) /Thunehed and Triumf 2005, 2006/ (Figure 2-3). The resistivity data were used, together with the results from the refraction seismic surveys /e.g. Lindqvist 2004a/, to calculate the total depth of the regolith /Thunehed 2006/. The results are shown on regolith depth maps /Thunehed and Triumf 2006, Thunehed 2006/.

The results of the resistivity measurements on the ground were used to calculate regolith depths from the EM data obtained during the helicopter-borne survey /Triumf et al. 2003/. The results are shown on a regolith depth map covering the whole area where the helicopter-borne investigation was carried out /Thunehed 2006/.

5.3 Physical and chemical properties

5.3.1 Physical properties

The results of analyses of physical properties include parameters such as grain size distribution, porosity and density of the most commonly occurring Quaternary deposits and soils.

Grain size analyses on material < 20 mm were carried out on a total of 84 samples from the terrestrial areas /Bergman et al. 2005, Rudmark et al. 2005, Sohlenius et al. 2006a, Morosini et al. 2007/ and 64 samples from lakes, wetlands and bays /Nilsson 2004/. The grain size distribution of coarse material (grain size 20–0.063 mm) was determined by sieving and on fine material (< 0.063 mm) by hydrometer analysis /Standardiseringskomissionen i Sverige 1992ab/.

The water content of peat and water-laid sediments was determined by /Nilsson 2004/. /Fredriksson 2004/ determined the water content in 40 samples from the uppermost sediments in the bay of Borholmsfjärden and other parts of the Simpevarp archipelago. The water contents were used, together with results from analyses of organic carbon content, to calculate the porosity and bulk density of the deposits. An average mineral grain density of 2.65 g/cm^3 /cf Almén and Talme 1975/ and an organic matter density of 1.0 g/cm^3 were used for these calculations.

The frequency of boulders and stones was determined within the soil survey /Lundin et al. 2005/ by pushing a 10 mm steel rod into the soil until a boulder or stone is hit within maximum depth of 30 cm /Viro 1958/. This was done at at 36 points at each investigated site. The frequency of stones was also determined in three of the machine-cut trenches investigated by /Sohlenius et al. 2006a/.

Samples from the four machine-cut trenches investigated by /Sohlenius et al. 2006a/ were analysed for soil physical properties. Volumetric mineral soil samples were taken using steel cylinders to determine dry bulk density, porosity, water retention and hydraulic conductivity.

Retention was analysed using porous suction beds and hydraulic conductivity using permeameters with constant head. The suction steps used were 10, 50, 100 and 500 cm water pressure. Conductivity values were determined after one hour flow and after 24 hours flow.

Most bulk density and porosity data were calculated from the samples taken by /Nilsson 2004, Fredriksson 2004/. These values were used because they are regarded as more representative for the different types of QD, whereas the measurements by Lundin were taken from the uppermost regolith (Z1 in Table 3-1), which has been affected by soil forming processes.

Specific surface was determined on eight samples by using the BET method /Brunauer et al. 1938/. That method uses gas adsorption for measuring the specific surface. The specific surface is a diagnostic parameter for the sorption capacity.

5.3.2 Chemistry and mineralogy

The chemical and mineralogical results comprise data from the most commonly occurring QD and soils in the regional model area. Most data were obtained from the site investigation but there are also data from SKB investigations conducted before the start of the site investigations. Data from geochemical analyses of till carried out within the SGU's regular mapping programme are also included in the present report.

Altogether 69 samples from lakes, wetlands and bays were analysed for total contents of carbon, nitrogen, sulphur, hydrogen and calcium carbonate /Nilsson 2004/. The content of $CaCO_3$ was also analysed in a total of 84 samples obtained during the QD mapping and the stratigraphical studies in the terrestrial areas. These analyses were done (grain sizes < 63µ) using Passon apparatus /Almén and Talme 1975/. /Fredriksson 2004/ determined content of organic matter in 40 samples from the uppermost sediments in the bay of Borholmsfjärden and other parts of the Simpevarp archipelago. These analyses were done by loss on ignition (550°C).

Eight clay, one sand and five till samples were analysed for mineralogy /Sohlenius et al. 2006a, Lundin et al. 2007/. The analyses were performed at SGU using X-ray diffraction. In till, minerals in the matrix fraction (grain size fraction < 2 mm) were determined qualitatively and quantitatively. Clay minerals in the clay fraction were determined separately. In clay, only minerals in the clay fraction (fraction < 2 µm) were determined. Qualitative analyses of the clay minerals were carried out with preferred orientation of clay mineral crystallites in three steps: sample in natural condition, sample saturated with ethylene glycol (EG) and sample heated to 400°C. Information from /Brindley and Brown 1984/ was used for identification of the clay minerals. The quantitative X-ray diffraction analyses were carried out in two ways: first by means of the method described by /Środoń et al. 2001/, somewhat modified, using mineral data from the SGU collection, and second by means of Rietveld techniques in TOPAS R software /Bruker AXS 2003/.

The distribution of clay minerals in four clay samples was analysed with X-ray diffraction by /Risberg 2002/. These sediments were obtained from a sediment core sampled in the bay of Borholmsfjärden south of the island of Äspö.

The rock composition of the till was studied in the boulder and gravel fractions /Bergman and Sohlenius 2007/. The aim was to determine whether the petrographical composition of the till corresponded to that of the local bedrock. The petrographical composition of till boulders was studied in two transects. The petrographical composition of the gravel gravel from till was studied using a stereo microscope.

The geochemistry of 77 samples (till, peat, sand, glacial clay and clay gyttja) was analysed /Sohlenius et al. 2006a, Engdahl et al. 2006, Lundin et al. 2007/. For the analyses of As, Cd, Cu, Co, Ni, Pb, B, Sb, Se and S, the samples were first dried at 50°C. The samples were thereafter digested in 7M HNO_3 and analysed with ICP-MS. The total contents of other elements were analysed after fusion in a carbon crucible with a flux (lithium metaborate) at 1,000°C. The "bead" which formed was dissolved in diluted HNO_3 and the metal concentrations were determined with ICP-MS. All results are presented as content/dry weight (105°C) /Sohlenius et al. 2006a, Engdahl et al. 2006, Lundin et al. 2007/.

Analyses of trace and major elements in till have previously been performed by SGU in and around the Laxemar-Simpevarp area with a sample grid of 1 sample 6/km^2 /SGU 2006/. That survey was carried out within the regular geochemical mapping programme of SGU. Data from that programme covers a large part of Sweden. The fine fraction of the till (< 0.063 mm) was digested in Aqua Regia and analysed using the ICP-AES-method. This fraction was also analysed with the XRF-method for total element analysis. The results were used to produce geochemical maps at the scale 1:1 million /Andersson and Nilsson 1992/. /Lindroos 2004/ used the results from SGU to evaluate the geochemistry of the model area in order to determine if there are any potential ore deposits in the neighbourhood. /Lindroos 2004/ also carried out additional analyses of trace and major elements on seven till samples obtained within the mapping of QD /Rudmark et al. 2005/. The seven till samples were analysed using the same method as was previously used by SGU /Andersson and Nilsson 1992/. The results from the seven new samples were later used together with the result from the investigation by SGU to visualise the geochemical trends in the model area.

The chemical composition of sediments and peat from a fen at the island of Äspö and the bays around Äspö was studied /Aggeryd et al. 1996, Landström et al. 1994/. These studies included the composition of both the pore water and the solid phase of the deposits. Major and minor elements were analysed by instrumental neutron activation analysis (INAA) and ICP. Radionuclides were analysed by alpha and gamma spectrometry.

A large number of radionuclides in peat and sediments from Klarebäcksmossen bog were analysed by /Lidman 2005/. For a description of the methods used in that investigation, the reader is referred to the report by /Lidman 2005/.

During the soil survey, /Lundin et al. 2005/ took samples of the upper regolith from ten land classes. A total of 20 sites with four to eight soil pits on each site were sampled. The samples were analysed for pH, carbon (C) and nitrogen (N). In the minerogenic soils, the uppermost organic layer was sampled separately. Beneath the organic layer, three samples were taken: 0–10 cm, 10–20 and 55–65 cm below the organic layer. In Podsol soils, the upper 5 cm in the B horizon was also sampled. Soil samples from the same levels were also taken in four of the machine-cut trenches studied by /Sohlenius et al. 2006a/. Additional samples were taken at fixed depths, from the ground surface down to the bottom of the trenches.

In the work to characterise the soils in the Laxemar-Simpevarp area, data were collected to calculate the carbon stocks for each dominant soil class. The soil carbon pools for each soil layer were calculated and added together using the following formula:

$$C_{pool} = \sum_{\text{i=soil layer}} (C_{conc}/100) \times BD \times DEPTH_i \times \left(1 - C_{stone}/100\right)$$

, where C_{pool} is the carbon pool (kg m^{-2}), C_{conc} is the carbon concentration (%), *BD* is the bulk density (kg m^{-3}), *DEPTH* is the layer depth (m), and C_{stone} is the stone content (%).

Samples from the four machine-cut trenches investigated by /Sohlenius et al. 2006a/ were analysed for soil chemical properties (33 samples). These analyses include determination of pH, C, N, exchangeable Ca, Mg, Mn, Na and K in 1 M NH_4Ac at pH 7, titratable acidity, extractable K and P in ammonia-acetate and 2 M hydrochloric acid (HCl). The soil contents of Fe, Al, Mn, Na, K, Ca, Mg and Zn were determined after extraction with Aqua Regia. One aim of these measurements was to determine the amount of available nutrients in the soils. Another aim was to compare the chemical soil properties of the soils in the Laxemar-Simpevarp area with those of the rest of Sweden.

Radiometric methods have been used to determine the rate of sediment accumulation and the rate of peat formation. The uppermost deposits were dated with ^{210}Pb. Determination of ^{137}Cs was carried out to verify the age depth model calculated from the ^{210}Pb measurements. The deeper and older deposits were dated with ^{14}C /Sternbeck et al. 2006/. The radiocarbon ages were converted to calendar years using the program CALIB 5.0 /Stuvier et al. 2005/. Results of previously performed radiocarbon dating by /Risberg 2002/ have also been used to calculate the rate of sediment accumulation in the bays. The accumulation rates were used to calculate the annual accumulation of organic carbon, nitrogen and phosphorus.

6 Results

Results of the investigations of Quaternary deposits (QD) and soils in the Laxemar-Simpevarp regional model area are described below. The results include maps showing the surface distribution of QD in the whole Laxemar-Simpevarp regional model area. A soil type map shows the distribution of soils in the terrestrial part of the model area. Stratigraphical results include data obtained from drilling, machine-dug trenches and geophysics. The chemical and physical properties of the most common QD and soils have been analysed and are discussed in this section. The surface and stratigraphical data have been used to construct a model showing the stratigraphy and total depth of regolith in the whole Laxemar-Simpevarp regional model area /Nyman et al. 2008/.

Both the marine and terrestrial parts of the investigated area are characterised by a relatively flat bedrock surface with numerous fissure valleys, which in many cases can be followed for several kilometres. The valleys represent zones where the frequency of bedrock fractures is denser than in the surroundings /SKB 2006c/. The highest topographical areas are dominated by till and bedrock outcrops. The valleys constitute areas that have been sheltered from wave erosion and coastal currents. These low topographical areas have therefore been favourable environments for sedimentation of clay for long periods of time. In the terrestrial part of the model area the groundwater level in the valleys is situated close to the ground surface. As a consequence, a layer of peat often covers the clay. Clay sediments are currently being deposited in the bays along the present coast. Exposed areas have been, and still are at some sites, subjected to wave washing, which has caused erosion and redeposition of some of the regolith. Sand and gravel is currently being transported at the bottom of the most exposed parts of the sea. A sand and gravel layer therefore often covers the valleys on the sea floor. More than 40% of the model areas consists of outcrops and areas with a thin layer of QD (a few dm). Remaining 60% consists of different QD, of which till is the most common (more than 30%).

Forest covers the areas dominated by till and exposed bedrock, which constitute the main part of the investigated area. The clay and peat in the valleys are, however, used as arable land in many places. Artificial ditches have lowered the groundwater level in these cultivated areas.

In a regional perspective, the Laxemar-Simpevarp area is situated in a region with relatively thin QD cover (Figure 6-1). There are areas with a more coherent QD cover, mostly till, west and south of the regional model area (Figure 6-1). In eastern Småland there are several large glaciofluvial deposits, mostly eskers, which have a northwesterly main direction. One of these deposits, the Tuna esker, crosses the western part of the Laxemar-Simpevarp regional model area. Figure 6-1 provides an overview of the distribution of QD in the Laxemar-Simpevarp region. The data, which were obtained during the site investigation, are, however, much more detailed (see below). The historical development of the Laxemar-Simpevarp area with surroundings is described in Chapter 4.

6.1 Bedrock in relation to regolith

The bedrock in the Laxemar-Simpevarp area, as well as in most of southeastern Sweden, is dominated by igneous rock that was formed c 1,80 million years ago and belongs to the Transscandinavian Igneous Belt /Söderbäck 2008/. The distribution of bedrock in the Simpevarp and Laxemar subareas has been mapped and the result is presented in /Wahlgren et al. 2005/. The bedrock in the Simpevarp subarea mainly consists of Ävrö granite, quartz monzodiorite and fine-grained dioritoid (Figure 6-2). Small areas with diorite to gabbro occur all over the Simpevarp subarea. Granite and diorites dominate the bedrock in the Laxemar subarea as well, along with small areas constituting of diorite to gabbro. The latter rock type has a higher content of easily weathered minerals compared to the other bedrock types. The glacial till in the Laxemar-

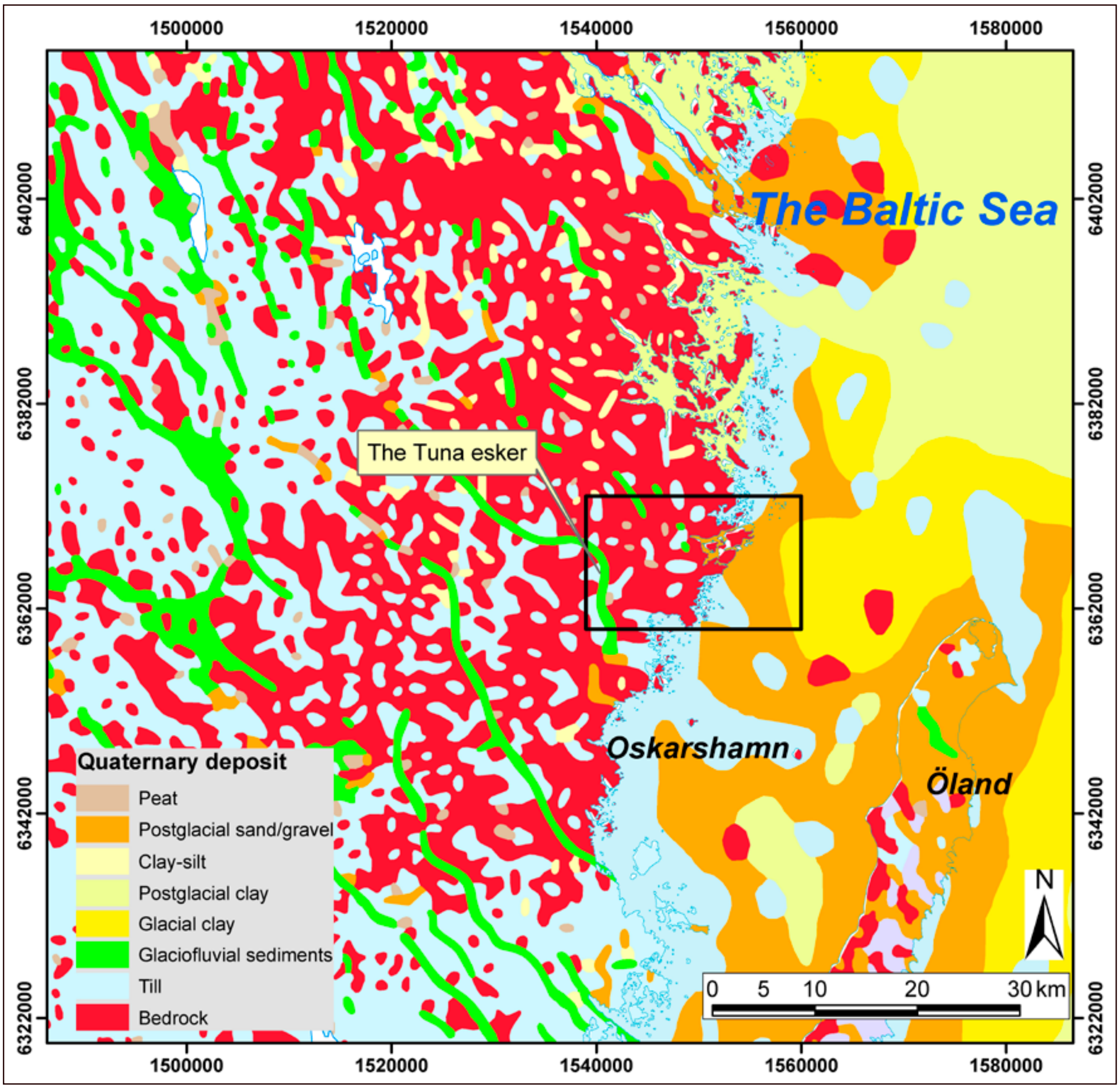


Figure 6-1. *The distribution of Quaternary deposits in the areas around the Laxemar-Simpevarp area /from Fredén 2002/.*

Simpevarp area mostly consists of fragments from the local bedrock (see Chapter 6.3.2). It is therefore possible that the areas with diorite to gabbro have locally different soil chemistry (e.g. higher concentrations of plant available nutrients), which may have resulted in richer vegetation in these areas. The possible relationship between soil chemistry, vegetation and local bedrock composition in the Laxemar-Simpevarp regional model area has not been studied. There are several long and narrow valleys in the Laxemar-Simpevarp area that often coincide with fracture zones. (Figure 6-2). It is possible that groundwater from the deep bedrock may reach the regolith and the ground surface through these fracture zones, For a thorough description of bedrock geology and fractures zones, in the Laxemar-Simpevarp are the reader is referred to the site descriptions of the area /SKB 2009/.

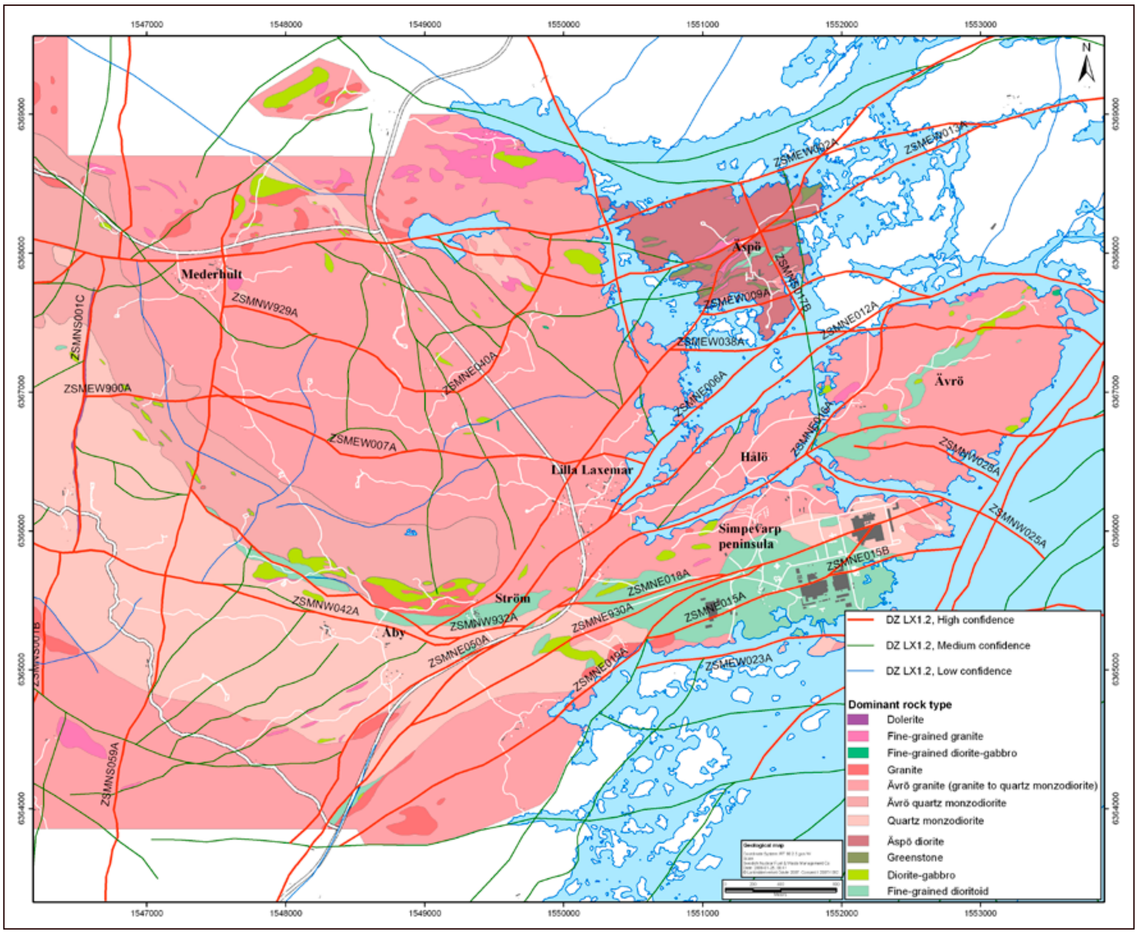


Figure 6-2. *Bedrock geological map of the Simpevarp and Laxemar subareas with surroundings /from Wahlgren et al. 2006/.*

6.2 Surface distribution of regolith

6.2.1 The terrestrial area

/Rudmark et al. 2005/ have presented a map and description of the regolith in the terrestrial part of the Laxemar-Simpevarp regional model area. In the present report the distribution of QD in the Laxemar-Simpevarp regional model area is shown on an overview map (Figure 6-4). The distribution of QD in the central part of the Laxemar subareas is shown on two more detailed maps (Figure 6-5, Figure 6-6). The legend for the deposits presented on the maps is shown in Figure 6-3. The proportional distribution of different QD in the terrestrial parts of the Laxemar-Simpevarp regional model is summarised in Table 6-1.

The local QD map (Area 1 and 2 in Figure 2-2) has been compared with the Property Map (Fastighetskartan), which shows different types of land use. That map was produced by the National Land Survey of Sweden. The results are shown in two tables (Table 6-3 and Table 6-4). Table 6-3 also shows the distribution of different land use in the whole local area. Most of the model area is covered by forest (86%). Many of the wetlands and almost all areas with till and bedrock outcrops are covered by forest (Table 6-3).

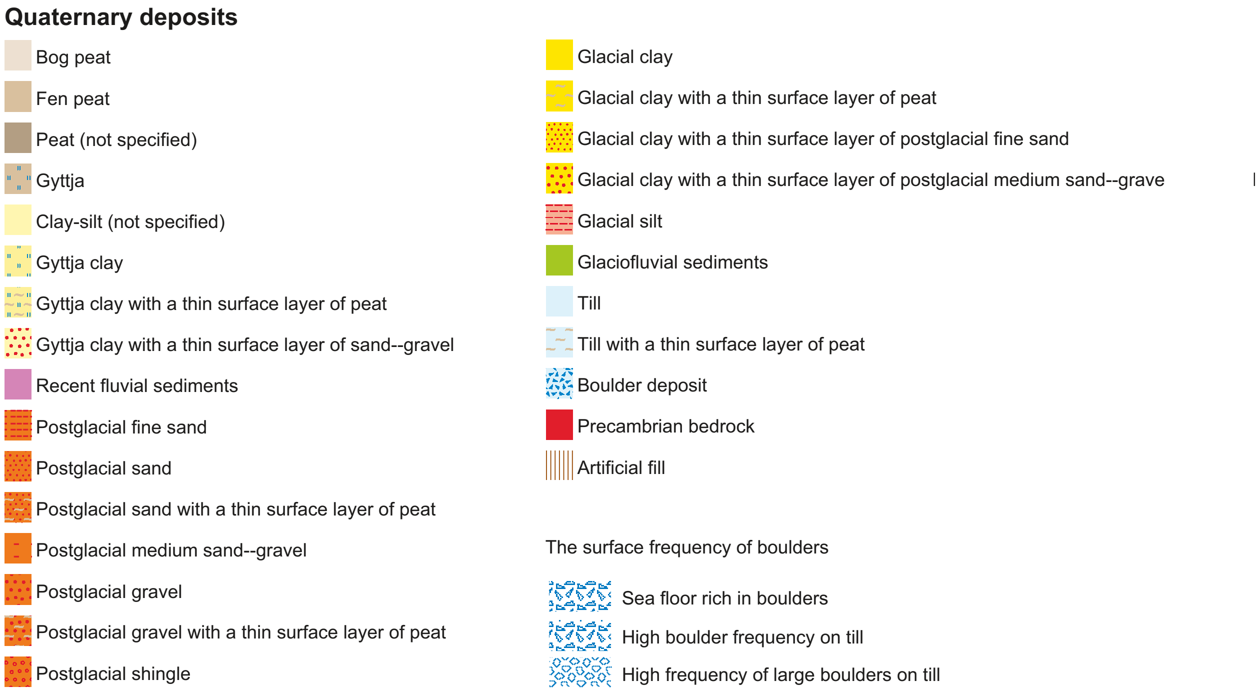


Figure 6-3. *The legend explains the different deposits shown on the QD maps.*

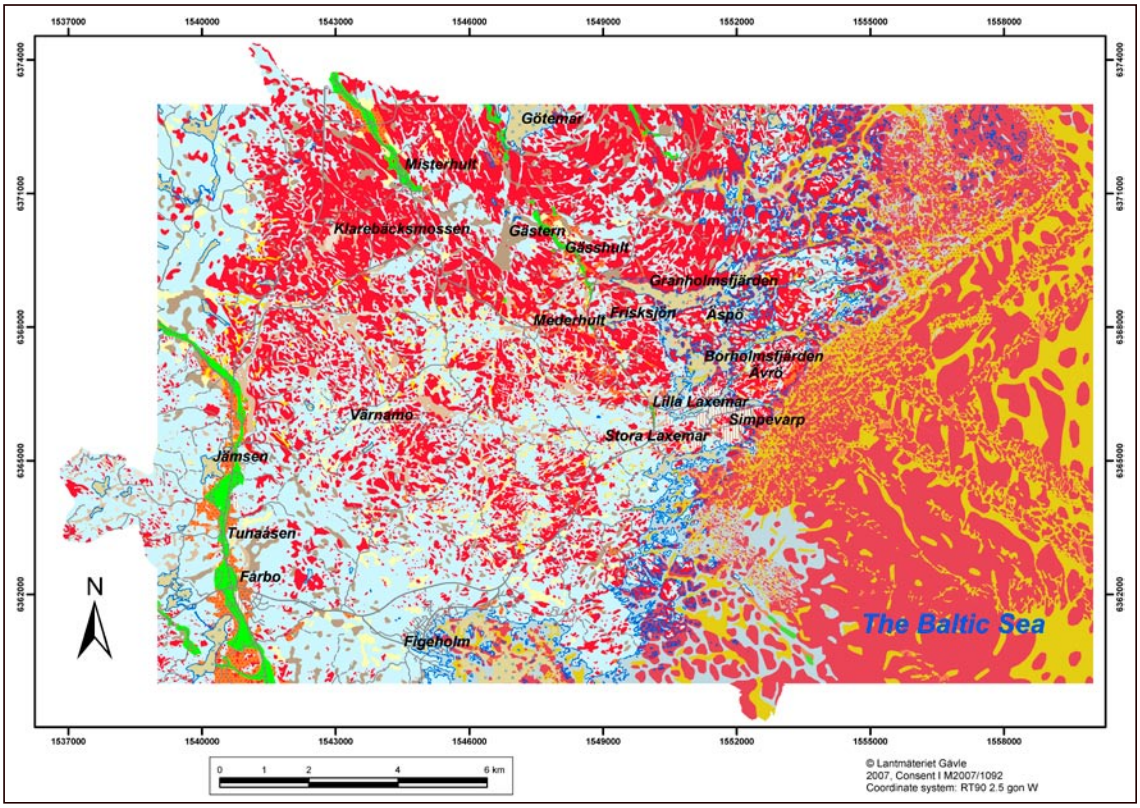


Figure 6-4. *The distribution of QD in the Laxemar-Simpevarp regional model area. The distribution of areas where different mapping methods were used is shown in Figure 2-2. Areas currently covered with water are shaded with grey.*

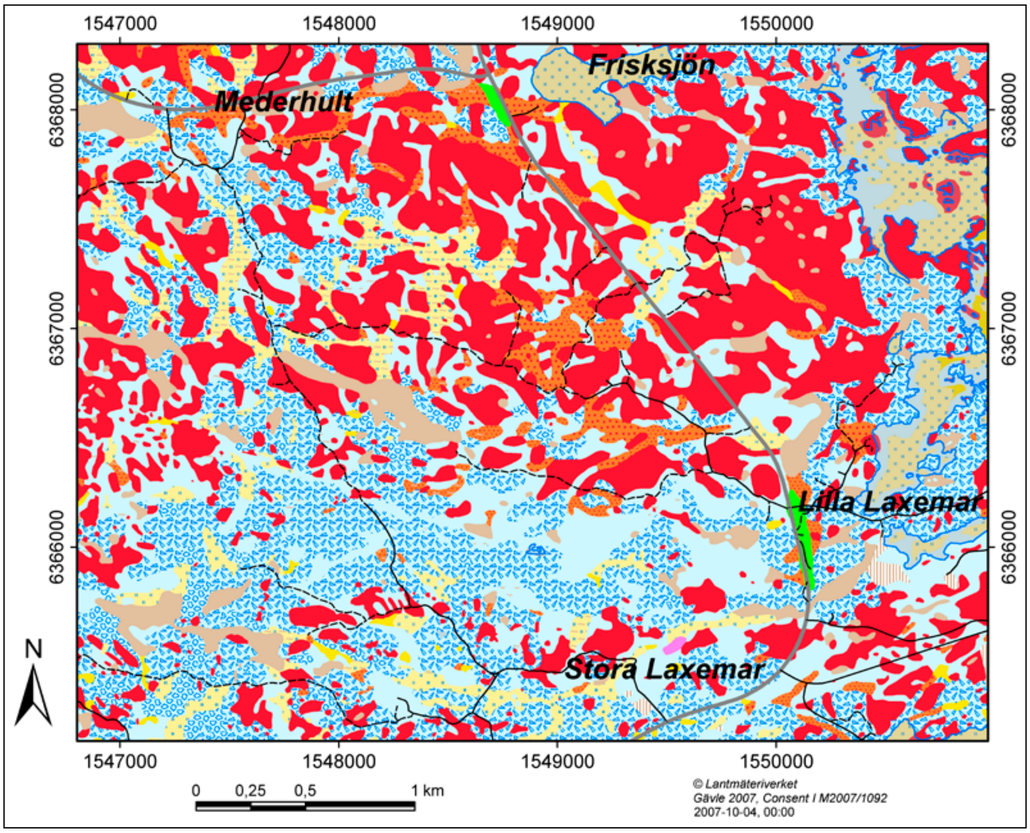


Figure 6-5. *The distribution of QD and the surface frequency of till boulders in the central part of the Laxemar-Simpevarp area. Areas currently covered with water are shaded with grey.*

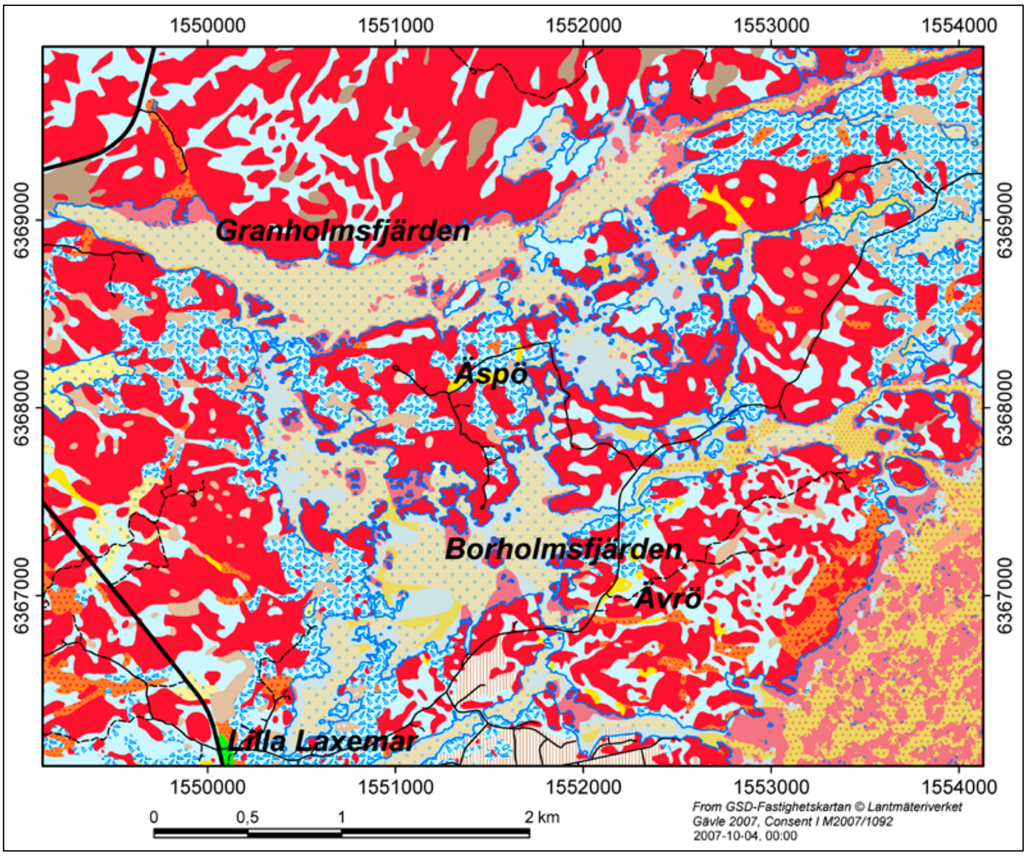


Figure 6-6. *The distribution of QD in the bays Granholmsfjärden and Borholmsfjärden with surroundings. Areas currently covered with water are shaded with grey.*

Table 6-1. The proportional distribution of QD in the terrestrial part of the Laxemar-Simpevarp regional model area. The local area includes the whole area mapped on a scale of 1:50 000 and 1:10 000 (Area 1 and 2 in Figure 2-2). The regional area has mainly been mapped using aerial photos (Areas 3 and 4 in Figure 2-2). * Areas with bedrock outcrops.

Quaternary deposit	Coverage (%) Local area	Coverage (%) Regional area	Coverage (%) Laxemar subarea	Coverage (%), Simpevarp subarea
Peat	8.0	7.6	5.3	1.9
Clay gyttja	3.4	3.3	5.8	0.1
(postglacial clay)		(*all clay and silt*)		
Glacial clay and silt	1.4		0.7	1.1
Glaciofluvial sediments	3.0	1.4	0.1	0.0
Postglacial sand and gravel	4.3	1.3	4.8	5.8
Till	43.3	51.7	45.2	35.0
Precambrian bedrock*	34.5	34.6	38.2	38.2
Artificial fill	1.3	0.13		17.9

Bedrock outcrops

Altogether c 35% of the terrestrial part of the regional model area consists of bedrock outcrops or areas with a thin cover (a few dm) of QD (Table 6-1). These areas are referred to as Precambrian bedrock in Table 6-1 and in the legend (Figure 6-3). Most of these areas (red on the maps) are, however, areas where the bedrock is not covered by QD. A thin layer of mosses, lichens or other vegetation often covers the bedrock in these areas. The frequency of exposed bedrock varies within the investigated area. Certain areas, e.g. the southern part of the Laxemar subarea and the area to the west of the Tuna esker, have a relative low frequency of exposed bedrock. On the other hand, areas in the north and in the archipelago have high frequencies of exposed bedrock.

The bedrock outcrops are rich in fractures at some sites, and it can therefore sometimes be difficult to determine if an area should be characterised as till or an outcrop (Figure 6-7).

The distribution of QD in the terrestrial part of the Laxemar-Simpevarp regional model area (Table 6-1) has been compared with the distribution of QD in the southern half of Sweden (Table 6-2). The frequency of exposed bedrock is relatively high in the model area. The reason for this is not fully understood. The model area is entirely situated below the highest shoreline.

Table 6-2. The distribution of QD in the areas covered by SGU local maps. These maps cover c 85,000 km^2 (2006) of the southern half of Sweden. The data represents QD from areas situated both above and below the highest shoreline. The area with a thin cover of QD represents areas with mainly till and bedrock exposures.

Quaternary deposit	Coverage
Peat and gyttja	8.9%
Clay and silt	19.7%
Postglacial sand and gravel	6.4%
Glaciofluvial sediments	5.6%
Till	41.0%
Thin coverage of QD	3.2%
Bedrock outcrops	14.7%
Artificial fill	0.2%
Other deposits	0.1%

Figure 6-7. *At some sites it is difficult to distinguish till from bedrock outcrops. The photo shows one such site (PSM005124), which was mapped as bedrock (photo: Lars Rudmark, SGU).*

Some of the present outcrops might therefore have been cleaned from overlying deposits by wave washing. There are, however, other areas in Småland, situated below the highest shoreline, which have a much more coherent QD cover, mostly till (Figure 6-1). It is therefore likely that the original primary till layer was thin or absent in large parts of the regional model area.

Till

Glacial till is the most common QD and covers half of the regional model area (Table 6-1). The result of geophysical and stratigraphical investigations (see below) suggest that the surface morphology of the till in general follows that of the bedrock. There are some areas in the southwestern part of the model area where the till forms low-relief hummocks (Figure 6-4). These small moraine hummocks were probably formed by more or less stagnant ice during the deglaciation. Low-relief moraine hummocks were also recognised in the till-dominated southern part of the Laxemar subarea /Bergman et al. 2005/, but are not shown on the QD map. Furthermore, refraction seismic surveys from that part of the Laxemar subarea suggest that the surface morphology of the till in that area not always follows that of the bedrock /Lindqvist 2004c/. One small but distinct moraine ridge was recorded during the mapping of QD /Rudmark et al. 2005/. That ridge is situated close to the Tuna esker in the northwestern part of the model area.

The frequency of boulders and stones of the till surface varies throughout the investigated area. In the Laxemar River drainage area around half of the till areas have a normal surface frequency of boulders. Most of the remaining till areas have high frequencies of surface boulders, but some small areas have a high surface frequency of large boulders. The uppermost till often has a relatively high content of coarse material compared to underlying till, probably as a consequence of wave washing. The ground at some sites is completely covered with boulders and stones (Figure 6-8). The internal frequency of boulders in till is in general intermediate /Rudmark et al. 2005/. According to the composition of the matrix the till is sandy or gravelly (see Section 6.4.1). In the field it was impossible to distinguish areas with sandy from areas with gravelly till, and all till areas are therefore shown as sandy on the map of QD.

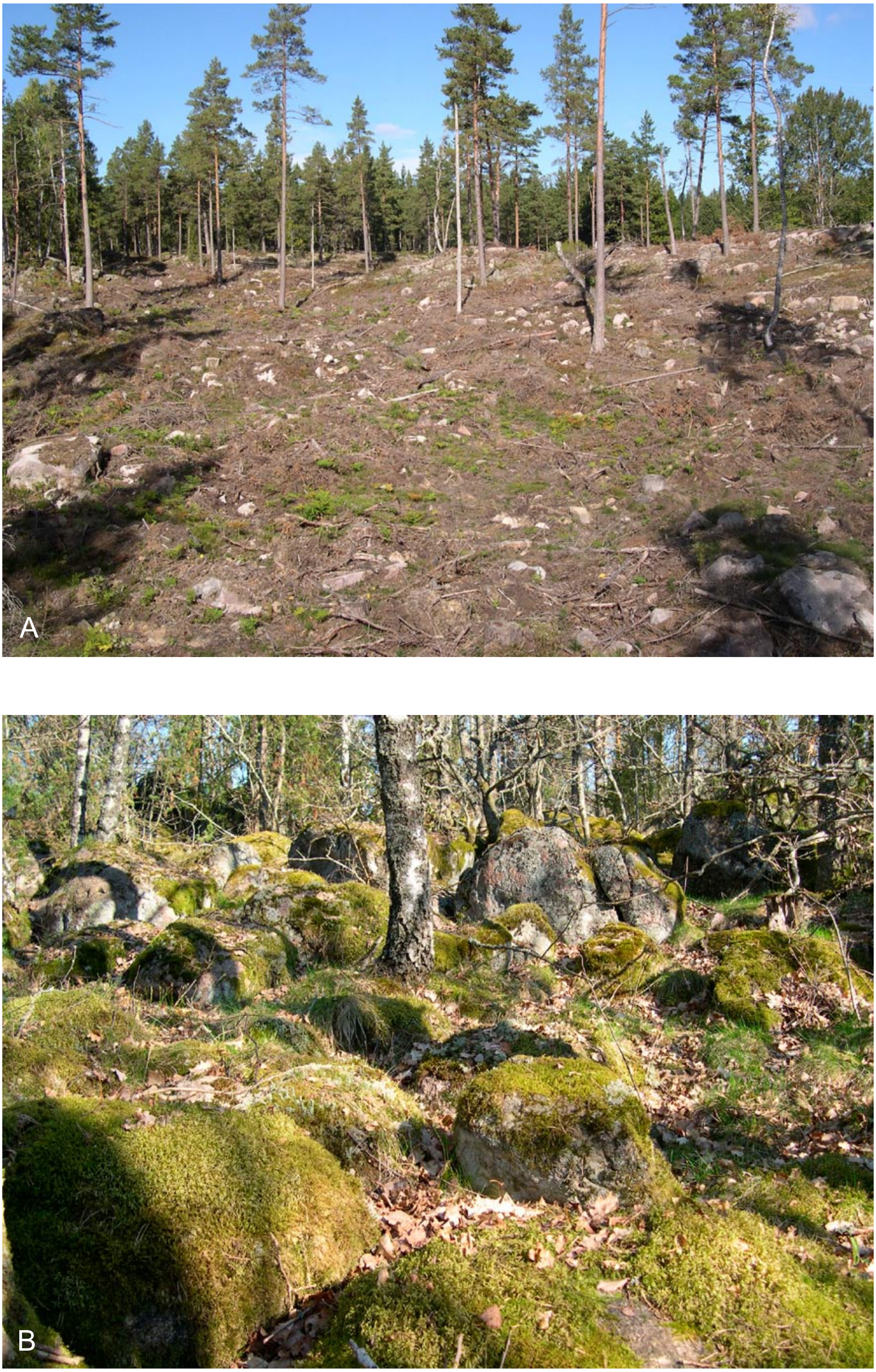


Figure 6-8. *The till surface is often rich in stones and boulders. The QD map of the central Laxemar-Simpevarp area (Figure 6-5) shows the distribution of till with different frequencies of boulders.* ***Figure A*** *shows an area with normal boulder frequency (Photo: Lars Rudmark, SGU) and* ***Figure B*** *shows an area with high boulder frequency (photo: Hanna Lokrantz, SGU).*

Glaciofluvial sediments

There are four glaciofluvial eskers in the model area. In the northern part of the area there are three relatively small eskers (Figure 6-4) with a north-south direction (the Gässhult esker, the Misterhult esker and a nameless deposit east of Lake Götemar). In the western part of the area there is a one considerably larger glaciofluvial esker, the Tuna esker, with a north-south direction, which in the north changes to a northwest-southeast direction. The Tuna esker, continues outside the model area (Figure 6-1). This esker is in a morphological sense the most prominent QD in the regional model area (Figure 6–15b). In general, the esker is 100–300 metre wide and 5–10 metre high. Heights up to 20 metre do, however, occur. Gravel and sand are the dominating grain sizes in the esker. The esker has been affected by wave erosion, which is reflected by raised beaches composed of sand and gravel on its sides. Alongside the Tuna esker there are wide flat areas of sand that have been washed out from the esker.

The groundwater resources in the Tuna esker have been estimated to be 5–25 l/s and the exploitation potential is therefore good /Pousette et al. 1981/. In the village of Fårbo close to Lake Fårbosjön, there is a municipal well with a protection area. In connection with the mapping work, a spring with a yield of about 1 l/s was detected at the foot of the esker, 5 km north of the village Fårbo /Rudmark et al. 2005/.

The three small eskers in the northern part of the model area have a gentle morphology and are not prominent eskers in a morphological sense. The Gässhultsåsen esker can be followed from Gässhult in the north southwards along the eastern side of the Laxemar subarea to Lilla Laxemar (Figure 6-5). During the QD mapping work it was not always possible to conclude whether sand and gravel around the esker are of glaciofluvial or postglacial origin. At some sites the occurrences of glaciofluvial sediments have been verified by stratigraphical investigations (see below). It is possible that some of the sand and gravel mapped as postglacial deposits are of glacial origin and viceversa. The postglacial gravel and sand often rests upon clay, whereas the glaciofluvial sediments rest directly upon till or bedrock. The groundwater resources in Gässhults esker are probably limited (< 1 l/s) /Pousette et al. 1981/. An attempt was made to measure the hydraulic conductivity of the Gässhult esker at SSM000230 close to Lilla Laxemar. The results were, however, unreliable /Johansson and Göransson 2006/. It is possible that the Gässhult esker has a continuation on the sea floor in the archipelago south of the Simpevarp Peninsula (see below).

Clay

Both glacial and postglacial clay were recognised during the QD mapping. The postglacial clay studied in the model area contains organic matter and is therefore referred to as clay gyttja (6–20% organic matter). Some of these clay sediments may, however, have an organic content lower than 6% (gyttja clay). Clay gyttja and glacial clay were distinguished from each other in the local area (Area 1 and 2 in Figure 2-2), but not in remaining parts of the terrestrial area /Rudmark et al. 2005/. Clay gyttja is common in the long and narrow valleys, which are characteristic for the model area (Figure 6-9). Fewer areas have been mapped as glacial clay. The transition between the flat clay fields in the valleys and the till and bedrock on the surrounding slopes is often sharp and clearly visible in the field (Figure 6-9).

A comparison between the model area and other areas along the coast of Småland that have been mapped by SGU shows that the proportional coverage of glacial clay is relatively small in the model area /e.g. Svantesson 1999, Rudmark 2000/. One reason for that may be that sand or postglacial clay covers a large proportion of the glacial clay in the model area. The frequency of areas covered by glacial clay on the sea floor is considerably higher than in the terrestrial parts of the model area. The reasons for this are discussed below.

Clay gyttja is the youngest clay sediment in the area and has been deposited in bays and along the coast. The clay gyttja is characterised by an almost white colour when dried. That can sometimes be seen when areas used as arable land are ploughed.

Figure 6-9. *Two valleys that demonstrate the typical distribution of QD in the Laxemar-Simpevarp regional model area. The floors of the valleys are covered with postglacial clay gyttja, which is sometimes covered with a thin peat layer. The higher areas constitute of bedrock exposures and glacial till. Many of these valleys are former fens, where the groundwater table has been artificially lowered for agricultural purposes (photos: Lars-Erik Olander and Lars Rudmark, SGU).*

The coverage of clay is relatively small in the Laxemar-Simpevarp area compared to other parts of southern Sweden (Table 6-1 and Table 6-2). Since clay is almost absent in areas situated above the highest shoreline that difference would have been even greater if the data presented in Table 6-2 was restricted to areas below the highest shoreline (like the Laxemar-Simpevarp area). The coast of Småland has, however, a relatively low coverage of clay (Figure 6-1). That coast is well exposed towards the Baltic Sea and only a small part of the sea floor is favourable for accumulation of fine-grained sediments. Erosion and reworking of earlier deposited sediments may further explain the low coverage of clay.

In the Laxemar-Simpevarp area the clay, especially the clay gyttja, is partly used as arable land. A comparison between the Property Map and the QD map shows that a large portion of the clay areas are not used as arable land and can be regarded as potential areas suitable for agriculture (Table 6-3, Table 6-4).

Recent fluvial sediments were only observed at one site close to Stora Laxemar (Figure 6-5) and are not shown in Table 6-1. These deposits are probably more coarse-grained than the clay in the investigated area. The fluvial sediments are probably deposited when the water is high in the neighbouring Laxemar River (Laxemarån).

It is possible that running water in watercourses has eroded clay deposits and exposed underlying till at some locations. The distribution of QD on the bottoms of watercourses was never investigated during the mapping of QD. /Carlsson et al. 2005/ have classified the deposits in some of the major watercourses. The results indicate that eroding water has not exposed the underlying till in most areas shown as fine-grained water-laid deposits on the QD map. However, /Carlsson et al. 2005/ found locations with stones and boulders at the bottoms of watercourses in areas shown as clay on the QD map. Most such locations were found close to the boundary between clay and till or in areas where the clay deposits have a relatively small geographical extent.

Postglacial sand and gravel

The effects of wave washing can be observed at many sites that have been or still are subjected to wave erosion. At some sites that have been exposed to extreme erosion, the uppermost till consist of a stony layer, shingle. Such an enrichment of stones can also be seen at several places along the present shore, especially on the island of Ävrö (Figure 6-10). Flat areas with postglacial sand occur in many depressions, where the sand often covers the glacial clay. Currents on the sea floor (see below) have to a large extent deposited the QD mapped as postglacial gravel and sand. Around one-third of the areas with postglacial sand/gravel is used as arable land (Table 6-3). A large part of the sand/gravel areas used for other purposes could probably be used for agriculture.

Peat

In the local area, the QD map shows two types of peatlands: bogs and fens. In the more generally mapped area, peat and other deposits rich in organic matter (e.g. gyttja) are symbolised in the same way on the map. The fens are characterised by sedges of different species such as reeds and moisture-seeking herbs. Many of the fens are small and situated in bedrock basins. There are several small bogs in the areas dominated by bedrock outcrops, e.g. on the northern part of the island of Ävrö. All areas covered with peat are or have once been wetlands. Most of the larger fens have, however, been drained by various types of ditches and are presently used as arable land or for forestry growth. In fact, only c 21% of the present areas covered with peat are wetlands according to the Property Map (Table 6-3). However, many small peat-covered wetlands not shown on the Property Map were observed during the mapping of QD (Rudmark personal com.). The area covered with wetland is therefore probably underestimated on the Property map. The peat in the drained areas is slowly oxidising and the underlying deposits, often clay gyttja, are slowly being exposed. A thin peat layer often overlies the clay gyttja in areas used as arable land. The largest peatland that has not been drained is probably the bog Klarebäcksmossen (Figure 6-4), a bog surrounded by fen peat.

Table 6-3. Land use on the most common Quaternary deposits in the area covered by the local map (Areas 1 and 2 in Figure 2-2). The different types of land use were taken from the Property Map (Fastighetskartan) (Lantmäteriet).

	Arable land* (%)	Open areas (%)	Forested areas, including clear-cut areas (%)	Wetlands (%)
Bedrock outcrops	0.2	2.8	96.6	0.4
Till	1.2	3.3	94.6	0.8
Glaciofluvial sediments	2.0	28.3	69.6	0.1
Glacial clay	28.8	9.2	60.6	1.4
Postglacial sand/gravel	31.5	16.7	51.2	0.6
Clay gyttja	50.4	12.6	32.6	4.4
Peat	12.3	7.2	59.2	21.3
Total area (%)	5.1	6.3	86.2	2.4

*Arable land refers to land used for cultivation of crops.

Table 6-4. The proportion of Quaternary deposits on the areas used as arable land.

Quaternary deposit	%
Till	10.6
Glaciofluvial sediments	1.2
Glacial clay	7.1
Postglacial sand	22.1
Postglacial gravel	4.4
Clay gyttja	33.9
Peat	20.6

Figure 6-10. *The whole Laxemar-Simpevarp regional model area is situated below the highest shoreline. Areas that have been exposed to the sea have subsequently been subjected to erosion by waves. These processes are still active along the present coast. The photo shows a shingle field on the island of Ävrö formed by erosion of glacial till (photo: Lars Rudmark, SGU).*

Artificial fill

At the Simpevarp peninsula around the Oskarshamn power plant the ground, has been changed by human activities. That explains the large proportion of artificial fill on the Simpevarp peninsula (Figure 6-11). The old QD map shows that the area where the nuclear power plant is situated used to be covered by till /Svedmark 1904/.

6.2.2 Marine and lacustrine areas

Figure 6-4 shows the distribution of QD on the sea floor within the Laxemar-Simpevarp regional model area. Figure 6-6 shows the typical distribution of QD in the bays, and Figure 6-11 shows the typical distribution of QD on the sea floor outside the archipelago. Parts of the deepest areas were mapped by SGU /Elhammer and Sandkvist 2005/, and parts of the archipelago and shallow areas by /Ingvarson et al. 2004/. Results from the regular SGU mapping programme were also included in the marine geological map. One area, the bay of Granholmsfjärden (Figure 6-6), was mapped by both SGU and /Ingvarson et al. 2004/. /Kjellin 2007/ interpreted the distribution of QD in areas that have not been mapped. The proportional distribution of regolith and bedrock outcrops in the marine areas is shown in Table 6-5. The morphology of the landscape is similar on the sea floor and in the terrestrial parts of the regional model area. The narrow depressions covered with sediments can in some cases be followed for several kilometres. The water depth in the valleys on the sea floor is often 15–20 metres, but more than 30 metres in certain areas. The distribution of regolith on the sea floor is also similar to that in the terrestrial part of the regional model area. Fine-grained, water-laid sediments (sand and clay) are present in the narrow valleys (Figure 6-11), which are surrounded by shallower areas dominated by exposed bedrock and till. Glacial clay is the most common type of clay in the marine areas, and is most often covered by a thin layer of postglacial gravel or sand. Postglacial clay (clay gyttja) is common in the bays along the coast, but it is almost absent outside the archipelago.

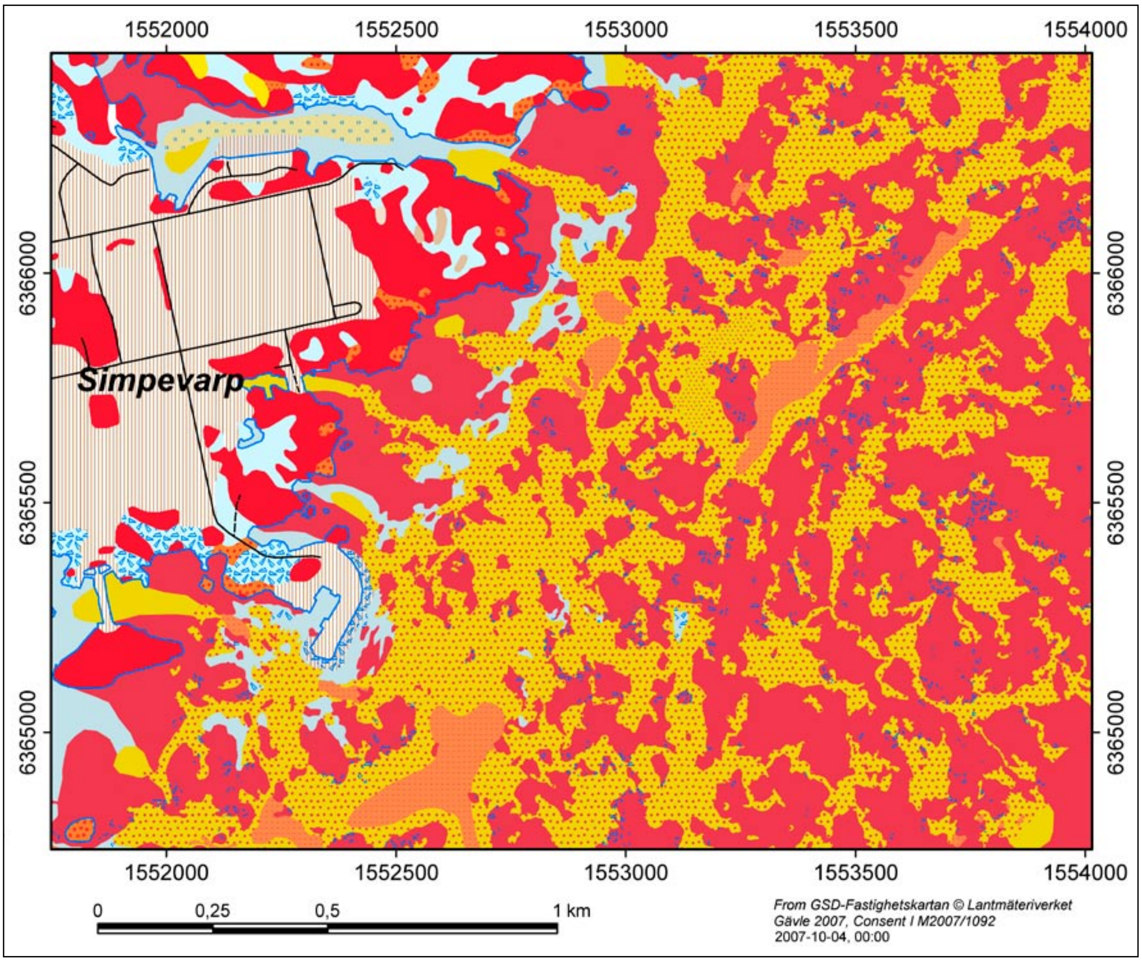


Figure 6-11. *The distribution of QD on the sea floor southeast of Simpevarp. Areas covered with water are shaded with grey.*

Table 6-5. The fraction (in %) of various types of Quaternary deposits on the sea floor. The table shows the distribution of QD in the following areas: 1. The bay Granholmsfjärden, 2. The Simpevarp detailed area, 3. Areas interpreted by /Kjellin 2007/, 4. Areas mapped within SGU's regular mapping program, 5. The Simpevarp local area, 6. Areas mapped by /Ingvarson et al. 2004/ and modified by /Kjellin 2007/, 7. The total marine area. The areas in the table correspond to different methods of mapping which are shown in Figure 2-2 and in Table 2-1.

	1	**2**	**3**	**4**	**5**	**6**	**7**
Areas in Figure 2-2	**7**	**5**	**10**	**8**	**6**	**9**	
Bedrock outcrops	35.4	51.6	52.1	80.6	63.4	43.4	53.6
Till	5.1	3.4	18.6	0	0.3	22.5	13.8
Glaciofluvial sediments	0	0	0.2	0	0	0	0.1
Glacial clay	13.4	41.6	24.7	16.9	31.0	33.1	28.1
Postglacial clay (clay gyttja)	44.0	0	4.2	0	4.3	0.7	3.9
Postglacial sand	2.1	3.3	0.2	2.5	1.0	0.3	0.7
Artificial fill	0	0.1	0	0	0	0	0

The proportional distribution of QD is similar in the whole marine area mapped by SGU (1, 2, 4 and 5 in Table 6-5). However, the sea floor in the narrow bay of Granholmsfjärden has a much higher proportion of postglacial clay (mostly clay gyttja, 1 in Table 6-5). Around half of the seafloor consists of bedrock outcrops. Adjacent terrestrial areas /Rudmark et al. 2005/ have a lower frequency of bedrock outcrops and a higher proportion of till (Figure 6-4). Over 40% of the land in the local terrestrial area is covered by till, whereas only a few percentage of the marine areas consist of till.

This difference in till coverage between the terrestrial and marine areas can be explained in at least two ways. 1) On land, the layers of till are often thin with a surface rich in boulder and stones /cf Rudmark 2004/. In the detailed marine area mapped by SGU around 7% of the bedrock is covered by a layer of boulders and stones /Kjellin 2007/. It is possible that the areas mapped as bedrock with a thin boulder and stone layer correspond to some of the till areas recorded in the terrestrial areas. 2) The proportion of till coverage varies considerably both within the marine and terrestrial areas, e.g. some of the areas mapped by /Ingvarson et al. 2004/ have a rather high proportion of till (6 in Table 6-5) whereas some of the terrestrial areas around Lake Götemar have a low proportion of till. It is therefore possible that both the marine and terrestrial areas are characterised by a varying proportion of till coverage. Furthermore, in the marine area the QD map has the highest quality in the areas denoted 1, 2 and 6 in Table 6-5. The QD map has a lower quality in remaining marine areas. It is therefore possible that there are areas with a high proportion of till in the marine area that are not shown on the QD map (Figure 6-4).

There is no direct observation of any glaciofluvial sediments on the sea floor. However, Kjellin suggests that there is a continuation of the Gässhult esker on the sea floor in the archipelago south of Simpevarp. Glacial clay is the most common QD in the marine areas, and in some part of the investigated area more than 40% of the sea floor is covered by glacial clay. A layer of gravel or sand a few decimetres thick almost always covers the glacial clay. The surface of the sand is locally characterised by ripples, which shows that currents are currently moving the sand. The frequency of areas covered with glacial clay is much larger on the sea floor compared to the terrestrial parts of the Simpevarp subarea. One reason for the low frequency of glacial clay on the land map is that a layer of postglacial clay gyttja or sand often covers the glacial clay. However, that does not fully explain the large difference in areas covered by glacial clay. A second explanation for the low frequency of glacial clay on land is that erosion by waves and currents during land uplift has reduced the proportion of the coastal areas covered by glacial clay. Furthermore, the glacial clay was deposited shortly after deglaciation, when the shoreline was situated at or slightly below the highest shoreline. Compared to the valleys in the present land areas, the water depth was then a few tens of metres deeper in many of the valleys of the present sea floor. It is possible that these deeper bottoms were more favourable for deposition of clay.

No areas constituting of glacial clay were shown on the original map presented by /Ingvarson et al. 2004/. That was one of the main reasons for the re-interpretation carried out by /Kjellin 2007/. The map by /Ingvarson et al. 2004/ shows the distribution of QD at the surface of the seafloor, whereas the map by /Elhammer and Sandkvist 2005/ shows the distribution of QD at a depth of 0.5 metre below the surface of the sea floor. That explains some of the differences between the results of the two methods. Most of the gravel and sand on the map by /Ingvarson et al. 2004/ corresponds to the thin layers of gravel and sand that covers the glacial clay in the areas mapped by SGU. The areas with glacial clay consequently increased significantly after the re-interpretation by /Kjellin 2007/.

The deepest parts of the narrow bays surrounded by land (e.g. in the bay Granholmsfjärden) are covered with postglacial clay gyttja (Figure 6-6). The capacity of wave erosion is low in these bays, and sediment is accumulating on these bottoms even today /Sternbeck et al. 2006/. The depositional environment in the present bays was probably similar to the situation when the clay gyttja areas on the present land were covered by shallow water. Coring in the shallow bays north of Simpevarp, e.g. the bay of Borholmsfjärden, has also shown that the youngest sediments consist of postglacial, gyttja rich, clay /Risberg 2002, Nilsson 2004/. /Fredriksson 2004/ has sampled and characterised the bottom sediments in some of the bays that were not investigated during the mapping surveys, e.g. the bay of Borholmsfjärden. /Kenczek and Sunesson 2006/ classified hard and soft deposits on the floor of Borholmsfjärden, which was not studied during the mapping activities. The soft bottoms probably correspond to areas covered by clay gyttja. That information was used for interpreting the distribution of QD on the floor of Borholmsfjärden /Kjellin 2007/.

6.2.3 Soils

A map showing the geographical distribution of different soil classes was produced /Lundin et al. 2005/ based on soil survey data and geographical information, such as maps of QD, vegetation types and topographical data. The map presented in this report (Figure 6-12) is the updated version of the soil type map /Lindborg 2006/, since the original map was based on the old map of the Quaternary deposits and underestimated the areas with bedrock outcrops and thin soil cover. The update was done after a field check that showed that the vegetation map /Boresjö Bronge and Wester 2003/ overestimated the richness of the vegetation in the field layer. That has caused the underestimate of the areas with bedrock on the original map by /Lundin et al. 2005/. The numerous areas covered with peat and used as arable land have also been recognised on the updated soil type map. The update was done using the recent QD map /Rudmark et al. 2005/.

On the soil type map of the Laxemar-Simpevarp regional model area (Figure 6-12), the following soil types are shown:

Bedrock
This class consists of bedrock outcrops, with a tree layer that is missing or consists of sparse pines, and a field layer of dry heath type. This class was consequently assigned to bedrock areas with a field layer of dry heath type.

LP: Leptosol
This class covers a mosaic of bedrock outcrops and thin soils typically found at the highest altitudes in the area. In the model area, the ratio of the Bedrock class to the Leptosol class is approximately 50/50. The Leptosol class was assigned to areas that are shown as bedrock outcrops on the QD map and have an existing tree layer.

PZ/RG: Podsol/Regosol
This class consists of thin coniferous forest soils found on till and coarse sediment soil with fresh soil moisture class. This class was assigned to areas with coarse mineral soil according to the map of Quaternary deposits. Additional criteria were a tree layer of coniferous trees and no meadows or arable land.

PZ/RG-e: Regosol
This class is found in areas with fresh or partly dry soil moisture classes. The soil is mainly of a poorly developed Regosol type, rich in stones and boulders. The tree layer is dominated by pine. This class was assigned to areas located on glaciofluvial sediments and postglacial gravel or sand. Areas used as arable or other open land are not included in this class.

UM/RG: Umbrisol-Regosol
This class consists of deciduous forest soils with a fresh soil moisture class. Deciduous trees dominate the tree layer, although some mixed forests occur. This class was assigned to areas with till or coarse sediment soil. All arable land and meadows were excluded.

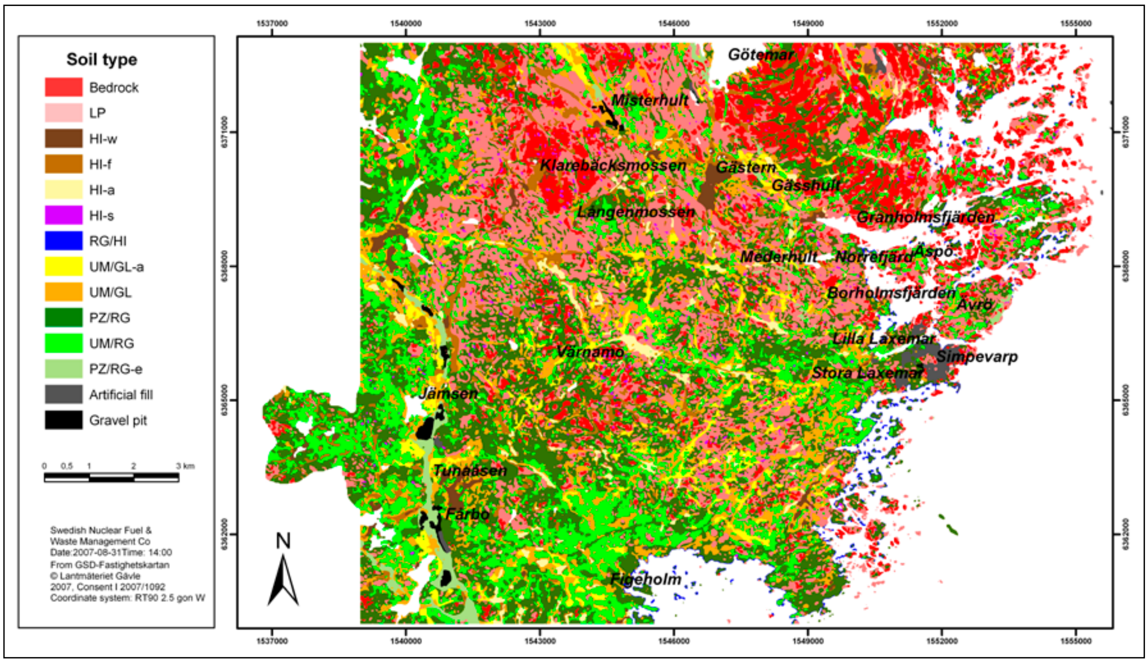


Figure 6-12. The distribution of soils in the terrestrial part of the Laxemar-Simpevarp regional model area. The map is based on field studies and interpretations of other geographical information such as maps of QD and vegetation. Since the most detailed mapping of QD took place in the Laxemar River drainage area, the soil type map is more reliable in that area.

UM/GL: Umbrisol-Gleysol
This class includes open pastures and partially forested moist soils at low altitudes. This class was assigned to areas with a ground layer of pasture and meadow type and areas with a high topographical wetness index value (> 9.5) on mineral soil parent material. Non-arable soil on clay and silt deposits was included in this class.

HI-w: Histosol, wetland
This class includes open wetland peat soils. The class was assigned to peatland areas with the exception of areas with any type of forest cover as well as arable land and meadows.

HI-f: Histosol, forested
This class consists of forested drained and undrained peatland soils. These soils are often forested with monocultures of spruce. This class was assigned to all peatland areas that have also had a forest cover. Arable land or meadows were excluded.

HI-a: Histosol, arable
This class consists of arable drained peatland soils. The class was assigned to peat areas were the ground layer was arable land or meadows.

HI-s: Histosol, small
This class covers small peatland areas that are formed in small depressions in the bedrock areas. The method for assigning areas to this class was different from the other classes. Among the areas with peatland according to the QD map, objects smaller than 0.5 ha with a topographical wetness index value smaller than 9.5 were selected. This included small peatland areas with a small catchment area.

RG/HI: Regosol/Histosol
This class is found along the sea shoreline and is influenced by closeness to water. The class is a mixture of mineral Regosol soils and organic Histosol soil. This class was assigned to shoreline areas along the coast and formed a 10 metre wide zone. Shoreline areas with bedrock outcrops were not included in this class.

UM/GL-a: Umbrisol/Gleysol, arable
This class includes arable land on fine textured sediment soils (Figure 6-13). The class was assigned to areas with clay or silt deposits according to the map of QD and arable land according to the Property Map. Many of the areas with this soil class are shown as postglacial clay gyttja on the map of QD.

Gravel pits
These are situated in areas with glaciofluvial sediments, where the soils have been artificially removed.

Artificial fill
This is material that has been placed in an area by humans. The material has not been significantly altered by soil forming processes. The largest areas with artificial fill are situated around the Oskarshamn nuclear power plant.

The spatial coverage of the different soil classes is summarised in Table 6-6. The results from the analyses of C, N and pH are summarised in Table 6-29 and are discussed in Chapter 6.4. Different types of Histosol are the most frequently occurring soils at the investigated sites (Table 6-6). However, Histosol only occurs in c 8% of the investigated area Table 6-6. Histosol is the most common soil type in the wetlands, which shows that many of the wetlands in the area are covered with peat. Histosol is also common in many areas, where ditches have lowered the groundwater level, e.g. in areas used as arable land. Podsol, Regosol and Leptosol are the most common types of soils and dominate areas covered by glacial till. A large part of the till areas are covered by deciduous forest. In these areas Umbrisol and Regosol are the most common soil types. The frequent occurrences of Regosol shows that the soil forming processes have not been active long enough to form diagnostic soil horizons at all investigated sites.

Figure 6-13. *A soil profile from a Gleysol formed on clay gyttja in an area used as arable land. The uppermost c 30 of the profile has a darker colour and is rich in organic matter. That layer has been affected by ploughing. The underlying layer has a greenish-grey colour with dots of rust that are typical of Gleysol.*

Table 6-6. Spatial coverage of the soil classes in the terrestrial part of the Laxemar-Simpevarp regional model area.

Soil class	Land class	GIS map soil class	Coverage (%)
No soil	*Bedrock outcrops*	Bedrock	11.1
Leptosol	*Mostly rock outcrops and till with coniferous forest*	LP	23.6
Podsol/Regosol	*Mostly till in areas with coniferous forest*	PZ/RG	25.2
Podsol/Regosol	*Glaciofluvial sediments with coniferous forest*	PZ/RG-e	1.4
Umbrisol/Regosol	*Deciduous forest in till dominated areas*	UM/RG	15.7
Umbrisol/Gleysol	*Meadows*	UM/GL	10.9
Histosol	*Forested peatlands*	HI-f	3.7
Histosol	*Open wetlands*	HI-w	1.7
Histosol	*Arable land, artificially drained*	HI-a	1.7
Histosol	*Small peatlands*	HI-s	0.6
Regosol/Histosol	*Shoreline areas, dominated by till*	RG/HI	0.6
Umbrisol /Gleysol	*Arable land, mostly artificially drained*	UM/GL-a	2.8
No soil	*Artificial fill*	Artificial fill	0.6
No soil	*Gravel pits*	Gravel pits	0.4

The area is completely situated below the highest shoreline, and many of the investigated sites have consequently only been subjected to soil forming processes for a few thousand years. This may explain the high frequency of Regosol.

There are areas where the type of land use has changed recently. Many small clay and peat areas that are forested today were used as arable land only 50 years ago /Jansson et al. 2004/. The soil properties in such areas are probably affected by that former land use.

6.3 Stratigraphy and total depth

Both the marine and terrestrial parts of the Laxemar-Simpevarp regional model area are characterised by large areas dominated by till and exposed bedrock, intersected by long and narrow valleys. The thickest regolith occurs in these valleys while the regolith thickness is generally low in other areas. There are, however, some exceptions to this rule. The glaciofluvial deposit in the western part of the model area, the Tuna esker, is a glaciofluvial esker that represents among the largest thicknesses of regolith in the model area, over 20 metres /data from SGU's well archive SGU 2007/. There are also areas, especially in the southwestern part of the regional model area, that are characterised by a coherent, relatively thick, till cover and few bedrock outcrops. There is also one such till-dominated area north of Stora Laxemar in the southern half of the Laxemar subarea (Figure 6-4).

6.3.1 Total depth

The total depth of QD in the terrestrial areas has been obtained from drilling, excavations and different geophysical surveys. The regolith depth data from the marine area were obtained from the geophysical investigation by /Elhammer and Sandkvist 2005/. The modelled regolith depths in the whole Laxemar-Simpevarp regional model area are presented in Chapter 6.3.3.

Results of drilling in the Laxemar subarea show that the depth of regolith often exceeds 10 metres in the valleys /e.g. Sohlenius et al. 2006a/. At one of the drilled sites (PSM007209), the depth of the QD exceeds 30 metres. Results of drilling in the terrestrial part of the Simpevarp subarea show regolith depths of between 1.5 and 8.6 metres. Most of the Vertical Electrical Soundings (VES) have been carried out in the Laxemar subarea and provide information on the total thickness of the regolith /Thunehed and Pitkänen 2003, Thunehed 2006/. The results from the 49 stations show that the thickness of the regolith varies between 0 and 14.5 metres. The thickest regolith was recorded in the valleys.

Seismic refraction recordings have been carried out in both the terrestrial part of the Simpevarp and Laxemar subareas and in the marine areas surrounding the Simpevarp subarea /e.g. Lindqvist 2005/. Almost 50 metres of regolith were recorded by /Lindqvist 2004b/ in a narrow strait north of Ävrö (LSM000192), which is the largest recorded thickness of QD in the whole model area. Most till areas are rich in bedrock outcrops and the average till thickness in these areas, obtained from refraction seismic, is 2.3 metres (Table 6-8). However, refraction seismic in the till covered area situated north of Stora Laxemar show that the regolith thickness in that area varies between 0 and 9 metres (average 3.6 metres). The till in that area is therefore thicker than the average for the two subareas. Furthermore, seismic refraction recordings from that part of the Laxemar subarea suggest that some of the hummocks in that area are composed completely of till /Lindqvist 2004b/. The seismic data set from the largest valleys indicates that the regolith depth commonly exceeds 10 metres in the largest valleys, which agrees with drilling results.

Electrical resistivity was measured along transects on the ground /Thunehed and Triumf 2005, 2006/ and the results were used to calculate the total depth of the QD. These results were used in the regolith depth and stratigraphy model /Nyman et al. 2008/, which is discussed below.

The helicopter-borne geophysical survey covers large parts of the terrestrial Laxemar-Simpevarp regional model area /Triumf et al. 2003/. The data were used to calculate the total depth of regolith in the investigated area /Thunehed 2006/. That was done after calibration with ground geophysical data and the QD map. The QD depth was calculated at points situated at a spacing of four metres along the measured lines. The results are presented as a regolith depth map. Each depth point represents the average regolith depth in an area with a diameter of 100 metres. The results of stratigraphical surveys and other geophysical surveys show that the landscape in the Laxemar-Simpevarp area is characterised by long and narrow valleys with a relatively thick layer of QD. The regolith depths consequently vary considerably within small geographical distances /e.g. Sohlenius et al. 2006a/. An area with a diameter of 100 metres could therefore represent a large span of different QD depths. Furthermore, an evaluation of the QD depths calculated from the helicopter-borne survey compared with results obtained from drilling and other stratigraphical studies shows that the geophysical data underestimated the QD depths in the valleys. The QD depth data from the helicopter-borne survey was therefore not used for the QD depth model produced by /Nyman et al. 2008/.

The depth of QD in the marine areas, investigated by /Elhammer and Sandkvist 2005/, has been measured at more than 140,000 points (Figure 2-2). Around 18,000 of these points were used to calculate the average depths of the different QD. The average depth of QD on the sea floor is 3.4 metre. Table 6-7 shows the average depth of the most common QD in the marine areas. As in the terrestrial areas, the thickest layers of regolith on the sea floor are restricted to the valleys, The total depth of regolith in the deepest parts of the depressions is typically between 5 and 8 metres, but depths over 10 metres are not uncommon. At one place, a regolith depth of almost 28 metres was recorded.

6.3.2 Stratigraphy

General stratigraphy

In the terrestrial part of the Laxemar-Simpevarp regional model area, stratigraphical information is available from machine-cut trenches, weight sounding, soil/rock drilling and different geophysical activities (Figure 2-3). The results from the seismic measurements in the marine areas provide detailed information on the total depth of regolith, but also on the thickness of the individual stratigraphical units /Elhammer and Sandkvist 2005/. The most reliable stratigraphical studies were done in the machine-cut trenches (Figure 6-14). The average thickness of the different QD in the terrestrial and marine areas is shown in Tables 6-7 and 6-8, respectively.

Figure 6-14. *Machine-cut trench in one of the pronounced valleys characterising the Laxemar-Simpevarp area. The photo was taken at site 3 in Figure 2-6 (photo: Gustav Sohlenius, SGU).*

Table 6-7. The average depth of regolith in the marine areas mapped by SGU. Only sites with a thickness larger than 0.5 metre were used for the regolith depth and stratigraphy model /Nyman et al. 2008/*. All data was obtained from seismic measurements.

Quaternary deposit	In the QD depth model*	N	Average depth (m)	Max (m)	Standard dev.
Till in the clay-covered valleys*	Z6	4,575	3.6*	27.2	2.6
Glacial clay	Z5	14,886	2.6	25.7	2.3
Postglacial sand	Z4	2,405	0.8	2.9	0.3
Clay gyttja	Z3	2,359	1.7	4.7	0.8

* All from drillings.

Table 6-8. The average depths of Quaternary deposits in the terrestrial areas. These data were used for the QD depth model presented by /Nyman et al. 2008/. All data, except the refraction seismic data (line 1), were obtained from drillings.

Quaternary deposit	In the QD depth model	N	Average depth (m)	Max (m)	Standard dev.
Till obtained from refraction seismic*	Z6	343	2.3	10.2	2.4
Till in the valleys**	Z6	65	2.0	6.6	1.3
Till in areas shown as till on the QD map	Z6	35	2.1	7.0	1.7
The Tuna esker	Z4	8	13.8	20.0	4.1
Other glaciofluvial deposits	Z4	18	4.1	9.0	2.3
Glacial clay	Z5	54	1.3	8.4	1.3
Postglacial sand	Z4	96	0.7	4.9	0.8
Clay gyttja	Z3	110	1.6	10.1	2.0
Peat	Z2	83	0.85	3.8	0.7

* Areas shown as till on the QD map, corresponding to topographical high areas. Data from the southern parts of the Laxemar subarea were excluded due to a large till thickness.
** Areas where other deposits, e.g. clay gyttja, covers the till.

The data set available from the terrestrial area is considerably smaller compared to that from the marine area. Data from land is, on the other hand, based to a greater extent on direct observations (e.g. drilling), whereas the calculated depths from the marine areas are based on interpretations of geophysical measurements.

Stratigraphical information from drilling and studies in machine-cut trenches in the terrestrial area is compiled in Appendices 1, 2 and 3. Results of the stratigraphical investigation carried out in lakes, bays and wetlands by /Nilsson 2004/ are shown in Appendix 4. These stratigraphical descriptions have been used for calculating the average thickness of the different QD (Tables 6-7 and 6-8).

The results of the stratigraphical studies of QD (Figure 6-15 and Figure 6-16) show that the till rests directly upon the bedrock surface. The following general stratigraphy was observed from the ground surface and down: peat, clay gyttja, postglacial sand, glacial clay and till (Table 6-9, Figure 6-16). The stratigraphical distribution of QD is similar in terrestrial areas to those covered by lake or seawater /e.g. Sohlenius et al. 2006a, Rudmark et al. 2005, Elhammer and Sandkvist 2005, Nilsson 2004, Johansson and Adestam 2004ab, Johansson et al. 2006/. Several of the stratigraphical descriptions presented in these reports are shown in Appendices 1, 2, 3 and 4. Unfortunately the descriptions are not always detailed enough for validation of the general stratigraphy in Table 6-9. For example, it is not always obvious from the descriptions whether sand and clay are of glacial or postglacial origin. There are several previous investigations from bays and wetlands in the Laxemar-Simpevarp area that describe the same general stratigraphical

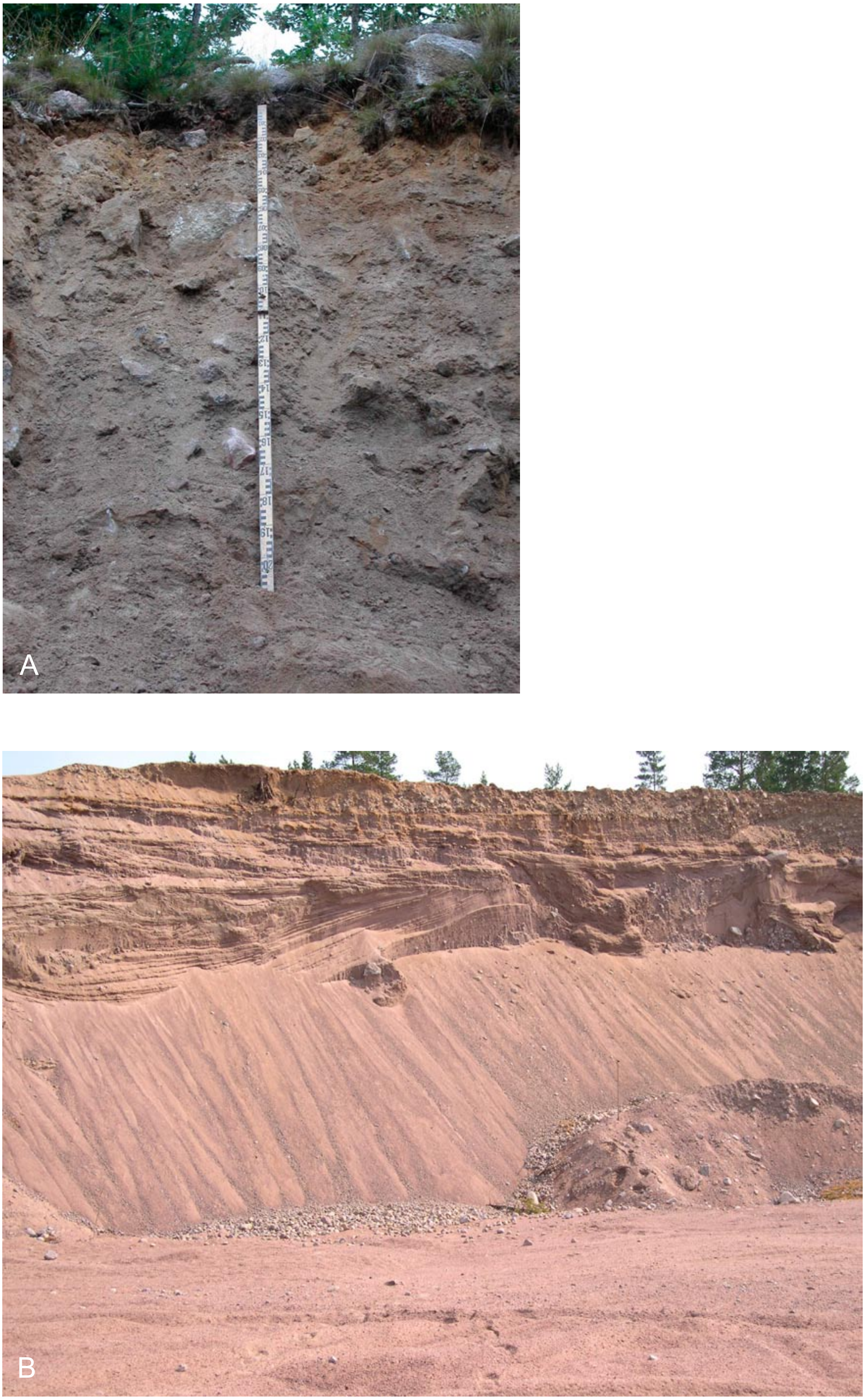
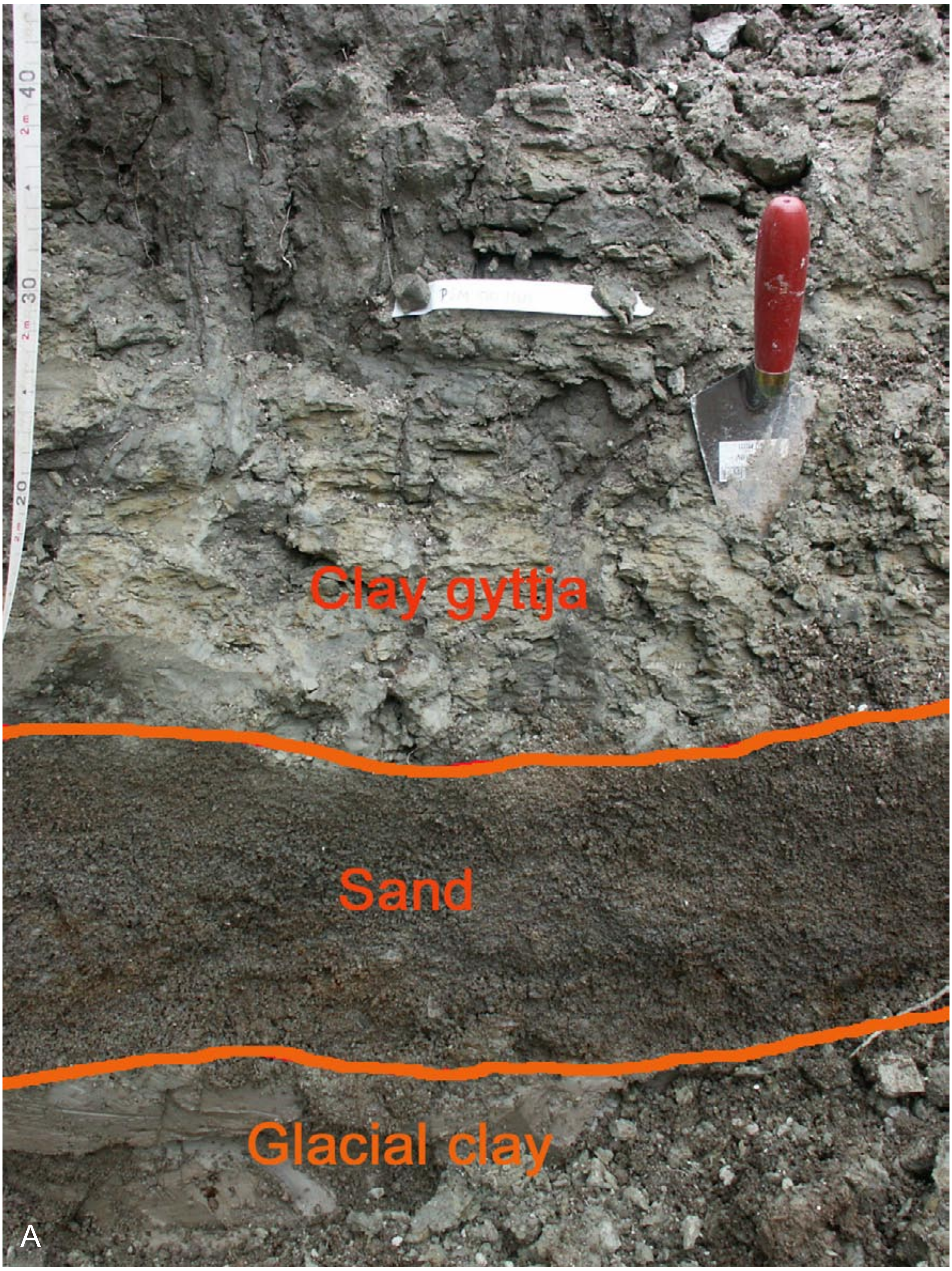


Figure 6-15. *Stratigraphical information was gained within several activities.* ***Figure A*** *shows the most common QD in the Laxemar-Simpevarp area, sandy till. The observation was made in a machine-cut trench (photo: Kärstin Malmberg Persson, SGU).* ***Figure B*** *shows the most prominent QD in the area, the Tuna esker, a glaciofluvial esker. The observation was made in a gravel pit north of Fårbo (photo: Hanna Lokrantz, SGU).*


Clay gyttja
Sand
Glacial clay
A

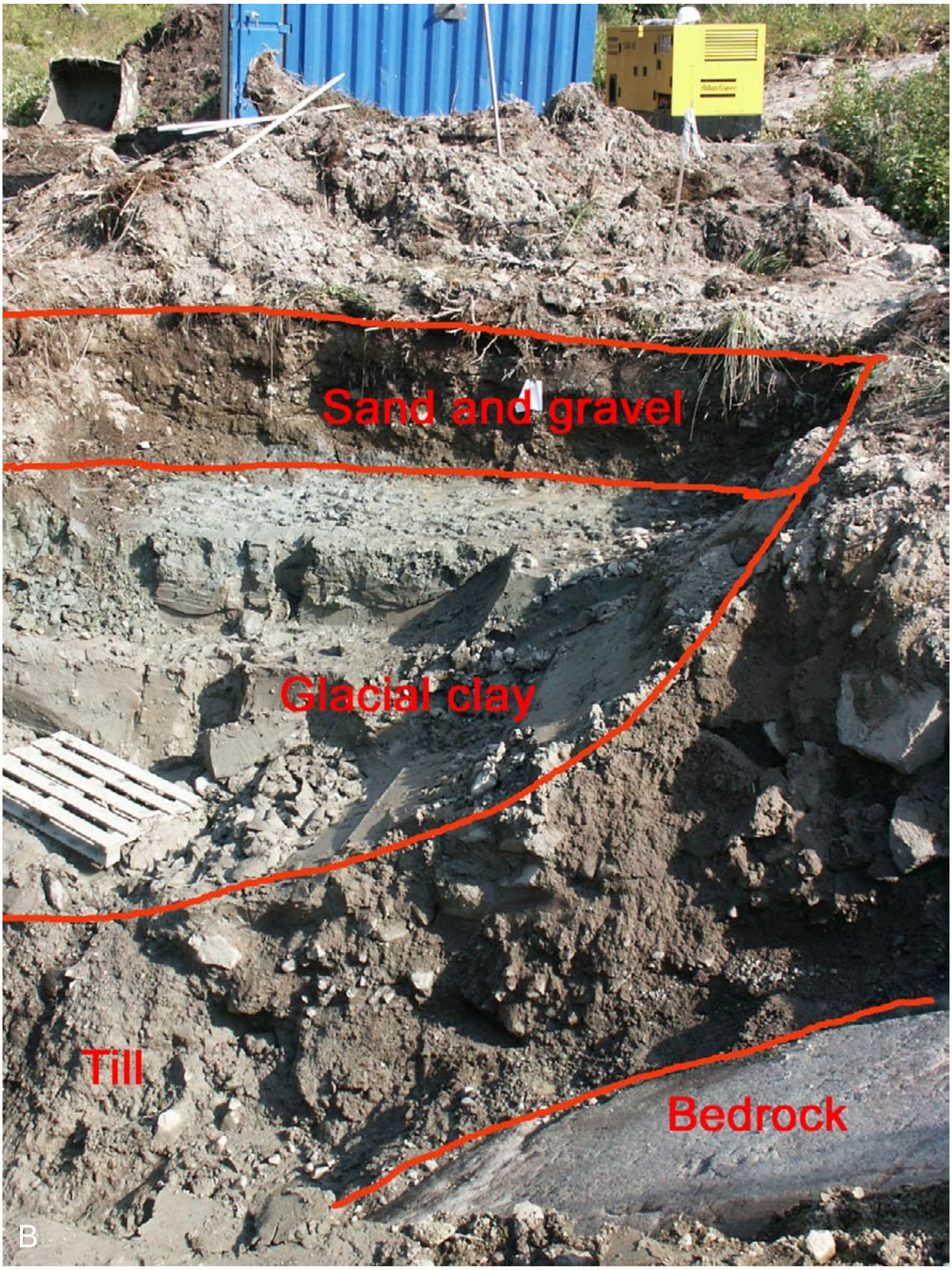


***Figure 6-16. Figure A** shows the typical distribution of water-laid sediments in the model area. The glacial clay was deposited shortly after the latest deglaciation. The sand layer is postglacial and represents a long period of erosion by streaming water on the sea floor. The uppermost, clay gyttja was deposited in a sheltered bay. The site is at present used as arable land (PSM007160, Site 1 in Figure 2-6). **Figure B** shows all QD overlying the bedrock in one of the valleys (Site 3 in Figure 2-6). The till was deposited during the latest glaciation and rests directly upon the bedrock. The till is overlain by glacial clay, which is overlain by postglacial sand and gravel (PSM007171, photos: Gustav Sohlenius, SGU).*

Table 6-9. The stratigraphical distribution of Quaternary deposits in the Laxemar-Simpevarp regional model area.

Quaternary deposit	Relative age
Bog peat	Youngest
Fen peat	↑
Gyttja clay/clay gyttja	
Postglacial sand/gravel	↑
Glacial clay	
Till	↑
Bedrock	Oldest

Table 6-10. The average depth and stratigraphy of QD in the domains used for the regolith depth model. The average depths of the different types of QD are presented in Tables 6-7 and 6-8. All bedrock outcrops and QD, except peat, have an uppermost Z1 layer (see Table 3-1), which is not shown in the present table.

Deposit on the QD map	Domain	Stratigraphy of the QD, from ground surface downwards	Average depths in the terrestrial areas (m)	Average depths in the marine areas (m)
Bedrock outcrops	1	No QD	0.1	0.1
Till	2	Till (Z6)	2.1	2.1
Clay gyttja	3	Clay gyttja (Z3), postglacial sand/gravel (Z4), glacial clay (Z5), till (Z6)	5.7	8.7
Peat	4	Peat (Z2),Till (Z6)	3.0	Missing
Peat	5	Peat (Z2), clay gyttja (Z3), postglacial sand/gravel (Z4), glacial clay (Z5), Till(Z6)	6.6	Missing
Glacial clay or postglacial sand/gravel	6	Postglacial sand/gravel (Z4), glacial clay (Z3), till (Z6)	4.1	7.1
The Tuna esker	7	Glaciofluvial sediments (Z4)	13.8	Missing
Other glaciofluvial deposits	8	Glaciofluvial sediments (Z4)	4.1	4.1
Artificial fill	9	Artificial fill (Z4)	5	5

distribution of the postglacial sediments as shown in Table 6-9 /Borg and Paabo 1984, Landström et al. 1994, Aggeryd et al. 1996, Risberg 2002/. The stratigraphy shown in (Table 6-9) is not always complete, which can be seen when studying the stratigraphies presented in Appendices 1, 2, 3 and 4. One example of this is the result from one of the machine-cut trenches (PSM007190), close to Mederhult, where gyttja rests directly upon the till. The stratigraphical studies carried out along the coast of Småland by /e.g. Lagerbäck et al. 2006/ have shown that a diamicton material (i.e. possibly till) sometimes covers the glacial clay around the glaciofluvial eskers. That observation does not agree with the stratigraphy presented in (Table 6-9). Even though no similar observations have been made in the Laxemar-Simpevarp regional model area, the possibility cannot be excluded that there are exceptions from the general stratigraphy in the model area as well.

Results obtained from studies in machine-cut trenches show that the uppermost bedrock at some places has a high frequency of open fractures. Laminated clay/silt has been found in some of these fractures /Sohlenius et al. 2006a, Rudmark et al. 2005/. These sediments were probably deposited before or during accumulation of the till and indicate that the crack must be older than the latest glaciation. In the machine-cut trenches, /Sohlenius et al. 2006a/ observed significant infiltration of water through the fractures in the uppermost bedrock (Figure 6-17 and Figure 6-18). Bedrock fractures may therefore be of importance for water transport in the transition zone between bedrock and QD. In one of the machine dug trenches (Site 4 in Figure 2-6) the bedrock was extremely rich in fractures and strongly altered by chemical processes Figure 6-18. It was even possible to dig through the uppermost "bedrock" with the excavator. In parts of that trench it was difficult to determine if the uppermost weathered material was formed in situ or was redeposited by the Quaternary ice sheets. In the other machine-cut trenches studied by /Sohlenius et al. 2006a/ it was not possible to reach the bedrock in the deepest parts of the valleys. It is, however, possible that strongly altered bedrock occur also in many of the other valleys in the Laxemar-Simpevarp area.

Till

The till has a matrix dominated by sand and gravel /e.g. Rudmark et al. 2005/ and was most likely deposited during the latest glaciation. Most of the till has a normal to high degree of consolidation. It is often rich in angular stones and small boulders representing the local bedrock type. The lowermost till in particular is rich in angular stones, indicating a very short transport distance. Laminae and lenses of sorted gravel, sand and silt occur unevenly distributed in the lowermost till. In some cases the lower part of the till is silty. The till lacks enough distinguishing characteristics to make a detailed genetic interpretation, but it can be concluded that it was probably deposited directly by moving ice (i.e. a lodgement till). However, the till at one of the sites (Site 4 in Figure 2-6) investigated during the studies in machine-cut trenches /Sohlenius et al. 2006a/ is relatively well sorted with respect to grain size and has a low degree of consolidation Figure 6-18. These characteristics indicate deposition under the influence of meltwater, i.e. a melt-out till. The

Figure 6-17. *Inflow of groundwater at the transition between bedrock and Quaternary deposits, observed in one of the machine-cut trenches studied by /Sohlenius et al. 2006a/ (Site 1 in Figure 2-6).*

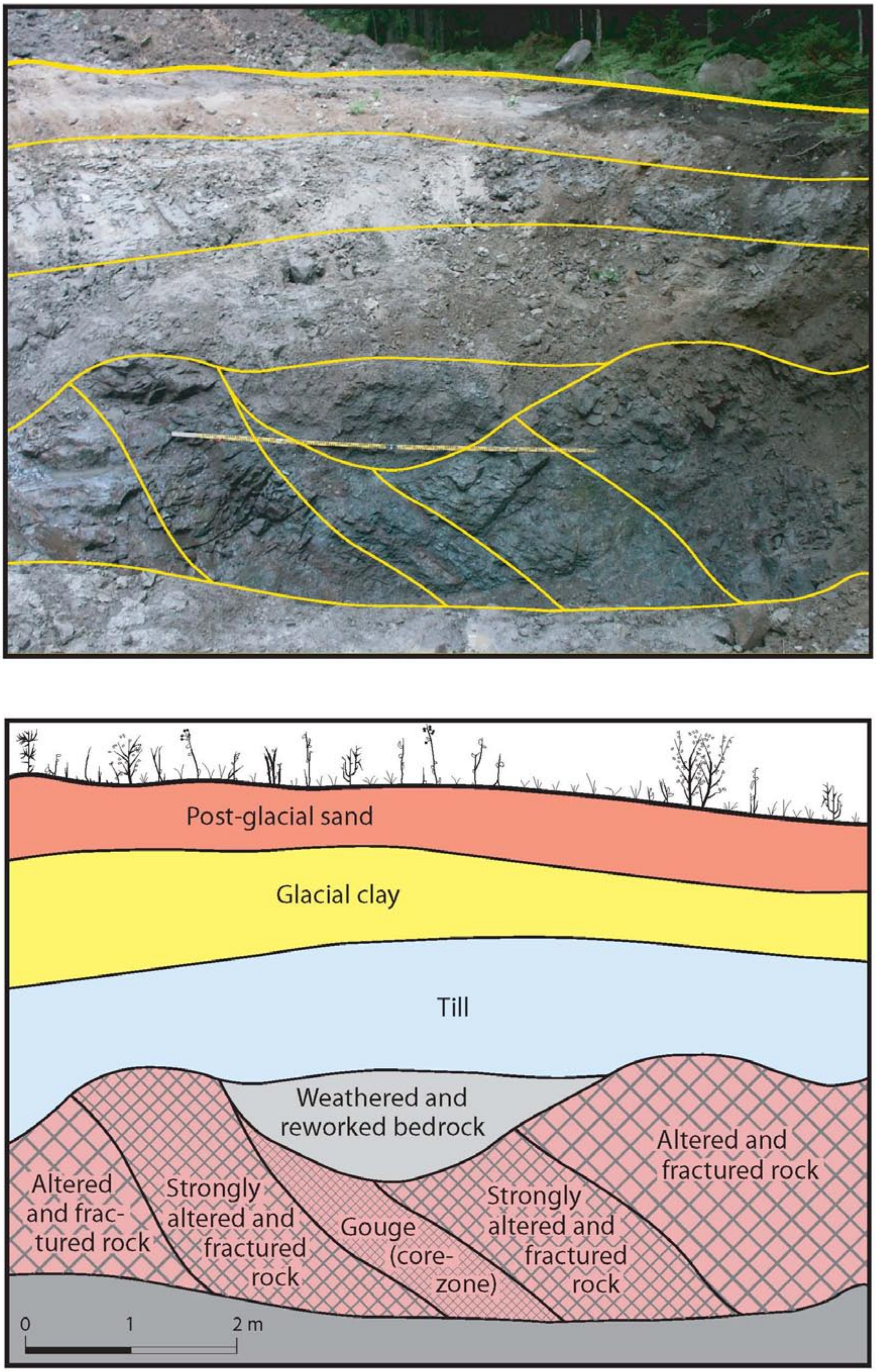


__Figure 6-18.__ Photograph and schematic illustration of the bedrock alterations, which were observed during the documentation of the excavation at Profile 4 (for location see Figure 2-6). The uppermost bedrock is rich in fractures and strongly altered. Inflow of groundwater was observed in the transition zone between bedrock and QD. The photo was taken towards north-west. The stratigraphical distribution of the Quaternary deposits overlying the bedrock is also shown in the schematic illustration.

fact that the bedrock surface generally has a rough, appearance indicates that the ice was not very erosive, but the main subglacial process was deposition of till /Rudmark et al. 2005/.

Data obtained from the drilling reported by /Morosini et al. 2007/ shows that the lowermost till at many sites (Figure 6-19), in the clay-covered valleys, is rather well sorted with respect to grain size and almost lacks fine material (silt and clay). These well sorted deposits have been classified as till in the field. However, the results of the grain size analyses indicate deposition by water (see Chapter 6.4). These well sorted till deposits probably have a considerably higher hydraulic conductivity than the till in general. In the case of some of the samples, the possibility cannot be excluded that the fine material has been washed out from the till during the sampling. Furthermore, some of the sand and gravel in the samples obtained from the drilling may originate from boulders and stones that have been crushed during the drilling. However, well sorted till material is present in samples from several drillings. It is therefore believed that the deposits overlying the bedrock in the valleys are better sorted than the till in general.

There are observations of clayey till in samples from soil/rock drilling in the Simpevarp subarea /Johansson and Adestam 2004ab/. Two samples have clay contents above 5% and are therefore classified as clayey till (Appendix 3). During stratigraphical studies of QD, /Sohlenius et al. 2006a/ observed lumps of clay in till underling glacial clay. /Sohlenius et al. 2006a/ suggested that the clay lumps in the till originate from the overlying clay. The possibility can therefore not be excluded that the clay in the till is due to contamination from overlying clay. Sandy-silty till was also observed in samples obtained from the drillings (Appendix 2 and 3). However, the results of grain size analyses (Appendix 5) do not confirm the occurrence of such fine-grained till in the model area.

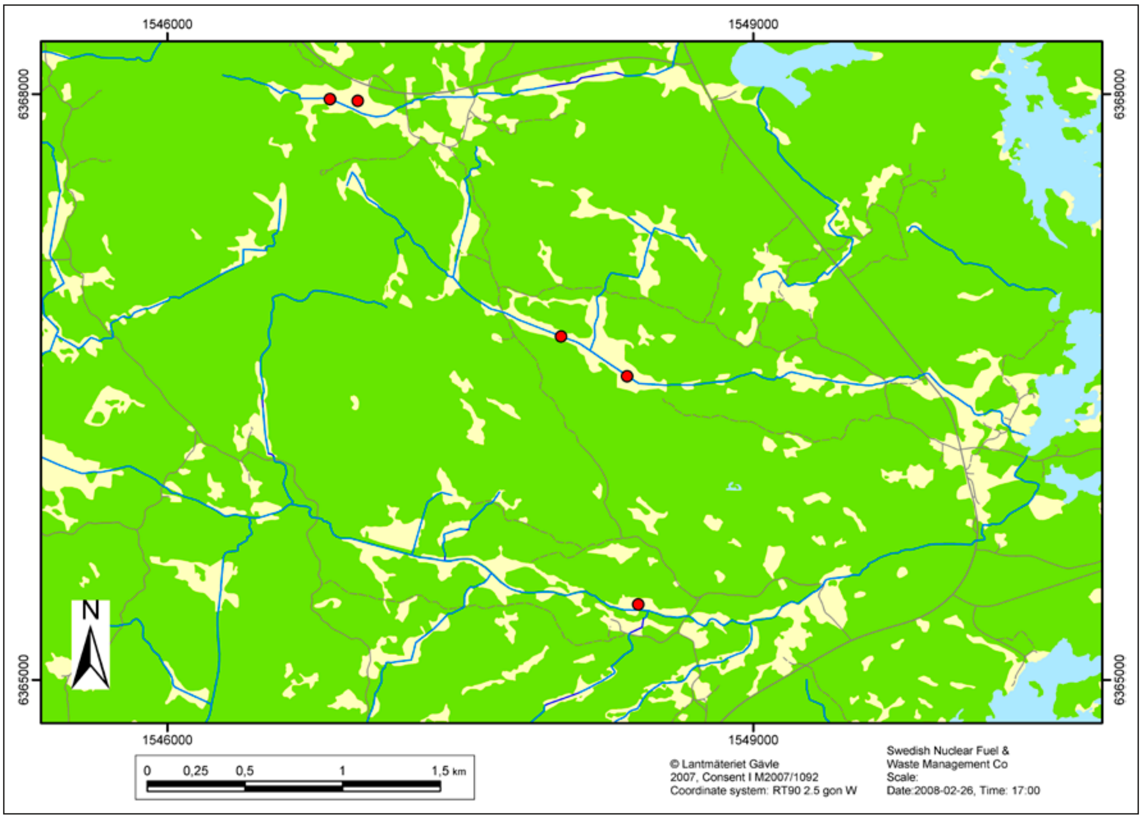


Figure 6-19. *Sites in the valleys where the till beneath the clay is rather well sorted with respect to grain size /Morosini et al. 2007/.*

In the Laxemar subarea, clasts of glacial clay were observed in a strongly consolidated till studied in one of the trenches where stratigraphical studies were carried out PSM005406 /Rudmark et al. 2005/. Glacial striations on the bedrock surface below that unit are from the northeast. This till unit may consequently have been deposited during an earlier phase than the main till, when glacial flow from the Baltic entered the area from the northeast. The clay clasts may then have been redeposited from the floor of the sea. At some other sites there are also indications that the till material derives partially from the Baltic depression. Two till samples from the same site, south of Lake Frisksjön, (PSM007171 and PSM007173) contain calcite /Sohlenius et al. 2006a/. The closest limestone areas are situated on the floor of the Baltic Sea, east and northeast of the area investigated here. Furthermore, the occurrence of striae from the northeast and results of till fabric analyses indicate transport from the floor of the Baltic Sea /Rudmark et al. 2005/.

/Bergman and Sohlenius 2007/ studied the petrographical composition of gravel and boulders in till from Laxemar subarea. They concluded that most boulders and gravel consist of bedrock types from the area. Many of the boulders have been transported 100 metres or less. However, single boulders and gravel grains have been transported several kilometres.

In the terrestrial areas the calculated average thickness of the till is c 2 metres, and the till thickness is more or less the same in the topographical low and high areas (Table 6-8). A higher value (3.6 metre) was recorded from the clay-covered valleys in the marine area (Table 6-7) mapped by /Elhammer and Sandkvist 2005/. The areas surrounding the valleys are totally dominated by bedrock outcrops in the marine area where the stratigraphical survey was carried out. There are consequently almost no measurements showing the average till thickness in the topographical high areas of the sea floor.

Glaciofluvial sediments

Results from the mapping of QD indicate that sand and gravel dominate the glaciofluvial sediments. The Gässhult esker has been studied by drilling and in machine-cut trenches. Drilling in the large valley between Lake Frisksjön and Mederhult (ZSMEW002a, Figure 6-2) show that the Gässhult esker partly rests directly upon the bedrock and partly is underlain by till. At one site close to the Gässhult esker, PSM007209, a depth of more than 30 metres of QD was recorded /Sohlenius et al. 2006a/. That is the thickest depth of QD recorded from the drilling in the Laxemar-Simpevarp regional model area. There is no proper stratigraphical description from that site and the total thickness of the glaciofluvial sediments is therefore not known. The average thickness of the Gässhult esker is, however, much smaller (Table 6-8). Stratigraphical studies in a trench situated in the peripheral part of the Gässhult esker west of Lake Frisksjön (PSM005401) indicate that the glaciofluvial sediments (c 2 metre) at that site are underlain by till /Rudmark et al. 2005/. A nearby trench (PSM005402) in the central part of the same deposit shows that the glaciofluvial sediments (c 3 metre) rest directly upon the bedrock. Data from SGU's well archive (8 sites) shows that the Tuna esker has an average depth of almost 14 metres. Data available from the three small eskers suggests a total average thickness of about 4 metres.

Glacial clay

The till in the valleys is often covered with glacial clay /e.g. Rudmark 2004/. At some sites a layer of silt was found in between the clay and the till /e.g. Sohlenius et al. 2006a/. Glacial clay is referred to here as clay with a low organic content, often below 0.5%, and represents both clay deposited during the deglaciation and younger clay deposited during the early Holocene phases of the Baltic Sea (the Yoldia Sea and Ancylus Lake). Some of the clay samples referred to here as glacial clay were characterised as postglacial clay during the site investigation /e.g. Nilsson 2004/. The clay deposited during the deglaciation of the Baltic Sea is commonly varved. During the studies in machine-cut trenches /Sohlenius et al. 2006a/ it was noted that the glacial clay almost completely lacks varves. However, at one site c 5 mm thick varves were recorded in the lowermost glacial clay. There are earlier reports of varved glacial clay close to Västervik north of the Laxemar-Simpevarp area /e.g. Svantesson 1999/. It is not known why the depositional environment in the investigated area has been unfavourable for the formation of varves. The lowermost glacial clay is often brownish and overlain by bluish glacial clay. It is possible that the bluish colour is due to diagenetic processes taking place after the deposition of the glacial clay. The sediments overlying the glacial clay are often rich in organic matter, which may have caused reducing conditions and the reduction of iron in the uppermost (bluish) glacial clay. Fragments of limestone, probably of Ordovician age, were found in the glacial clay. The closest limestone areas are situated on the floor of the Baltic Sea, east and northeast of the area investigated here. /Risberg 2002/ investigated the siliceous microfossil record in a sediment core (SAS 48) from the bay of Borholmsfjärden south of the island of Äspö. The sediment sequence consists of brownish clay overlain by bluish clay. The results show that both the bluish and brownish clays were deposited during the brackish phase of the Yoldia Sea. It is, however, not known whether the corresponding units described from other sites /e.g. Nilsson 2004/ was also deposited in the Yoldia Sea.

The average thickness of the glacial clay is considerably greater in the marine areas compared with the terrestrial areas (Table 6-7 and 6-8). One reason for that is that waves and currents caused by land uplift have subjected the glacial clay in the terrestrial areas to erosion. Another reason may be that thicker layers of glacial clay were originally deposited in the present marine areas, since the water depth was greater in these areas. There are large variations in the thickness of the glacial clay and in the marine area a maximum thickness of c 25 metre was recorded.

Postglacial sand and gravel

In the terrestrial area a layer of sand and gravel, at some places containing stones, commonly covers the glacial clay /e.g. Sohlenius et al. 2006a/. A corresponding sand layer overlying the glacial clay was observed during the marine geological survey /Elhammer and Sandkvist 2005, Ingvarson et al. 2004/ and is also described from the studies of sediment and peat in shallow bays, wetlands and lakes /Nilsson 2004/. The transition from glacial clay to sand/gravel is sharp and of an erosive nature. Currents on the sea floor probably deposited this layer. The sand and gravel have been redeposited by erosion of till and glaciofluvial sediments. The average thickness of the sand layer is 0.7 and 0.8 metre in the terrestrial and marine areas, respectively. Almost five metres of postglacial sand was recorded in one of the valleys in the Laxemar subarea (SSM000262). That sand layer may consequently be of importance for the hydrology in the clay-covered valleys.

Postglacial clay gyttja

At many sites a bed of clay gyttja or sometimes gyttja overlies the sand and gravel layer. There is a successive transition from silt-gravel to clay gyttja. The gyttja-rich sediments were deposited during the bay stage shortly before the sites emerged from the sea. Gyttja-rich sediments are currently also accumulating in the present-day bays /Sternbeck et al. 2006/. At one terrestrial site (PSM007190), bands of mollusc shells were found in the gyttja /Sohlenius et al. 2006a/. These shells represent species that indicate deposition in a brackish water environment (Erik Wijnbladh SKB, personal com). At another of the sites investigated by /Sohlenius et al. 2006a/ (PSM007170), the clay gyttja contained several diatom species which were common in the bays of the Littorina Sea (e.g. *Epithemia sorex*) (Anna Hedenström, SGU personal com). At that site the content of these siliceous fossils is so high that it affects the chemical and mineralogical properties of the clay gyttja (see Chapter 6.4). /Risberg 2002/ and /Kaislahti Tillman and Risberg 2006/ have studied the diatom composition in sediment cores from the present sea floor. They showed that the gyttja sediment have accumulated in a brackish water environment. In the lakes the clay gyttja is overlain by gyttja which is currently accumulating.

The average thickness of clay gyttja is similar (1.6 and 1.7 metres) in both the marine and terrestrial part of the regional model area Table 6-7 and Table 6-8. The calculated average depths include all gyttja sediments (e.g. gyttja, clay gyttja). The thickest recorded layer of gyttja sediment is more than 10 metres and was obtained from Lake Frisksjön (SSM000242). It is possible that the thickness of gyttja sediments is considerably greater than the average in some of the lakes and bays /cf Nilsson 2004, Sohlenius et al. 2006b/. In the marine area the thickness of the gyttja sediments was determined by sediment echo sounding /Elhammer and Sandkvist 2005/. It has not always been possible to determine the thickness of the clay gyttja due to the presence of gas in the sediment, which prevents penetration with the echo sounder. The average thickness of clay gyttja shown in Table 6-7 could therefore be an underestimate.

Peat

In many of the current wetlands, a layer of fen peat covers the gyttja sediments. At some sites the fen peat has been covered by bog peat. The largest area with bog peat is probably the mire Klarebäcksmossen (PSM006562). As mentioned above most of the former wetlands have been drained by ditches, but are still covered by a peat layer. The average thickness of peat (0.9 metre) was calculated by the use of data from /Nilsson 2004/ and /Rudmark et al. 2005/.

Several studies have shown that the peat is underlain by clay gyttja, post-glacial sand/gravel and glacial clay /e.g. Nilsson 2004, Sohlenius et al. 2006b/. Several areas with peat are small and surrounded by till and/or exposed bedrock /Rudmark et al. 2005/. These small peat areas probably correspond to the small water ponds, which can be seen in bedrock depressions along the coast. The ponds have gradually been filled up with peat. The peat in these small depressions is probably not underlain by thick layers of clay, which is the case in the large valleys. In the QD depth model it is therefore assumed that the small peat areas (domain 4) are underlain by till, which rests directly upon the bedrock.

The thickest layers of peat are found in wetlands, which are more or less unaffected by ditching, for example Klarebäcksmossen bog. Many peat areas are used as arable land, which is possible since ditches have lowered the groundwater table. The peat layer in these areas is relatively thin and is currently decreasing due to compaction and oxidation. Many areas used as arable land are shown as clay gyttja with a thin peat layer on the QD map, i.e. they have a peat layer thinner than 0.5 metre.

The stratigraphy from Långenmossen fen /Nilsson 2004/ differs from the one presented in Table 6-9. A clay layer overlain and underlain by gyttja was recorded at that site (PSM006564, 19 metres above the present sea level). This clay layer was possibly formed during the Ancylus transgression, more than 10,000 years ago (Figure 4-4), when the water depth in the area increased by almost 10 metres /cf Påsse 2001/.

6.3.3 The regolith depth and stratigraphy model

The regolith depth and stratigraphy model covers the whole regional model area and some adjacent areas (Figure 3-3). Data obtained from drilling and excavations were included in the model. Most of the results from geophysical investigations were also included. Data from the helicopter-borne survey /Triumf et al. 2003/ were, however, not used (see Chapter 6.3.1). There are large variations in the regolith depth within the modelled area. The largest depths were recorded in the clay-dominated valleys and on the glaciofluvial sediments. The area was therefore divided into nine domains, which were modelled separately (Figure 6-20). These domains were defined by means of the QD map (see Table 3-2). Since the density of data obtained from the site investigation varies (Figures 2-3 and 2-4), the accuracy of the map varies within the model area. The model includes the stratigraphical distribution of till, glaciofluvial sediments, glacial clay, postglacial sand/gravel, clay gyttja, peat and artificial fill. Six Z-layers were used to describe the stratigraphical distribution of the regolith (Figure 3-4, Table 3-1). For a thorough description of the model the readers are referred to a report by /Nyman et al. 2008/.

Figure 6-21 shows the modelled distribution of total regolith depths in the Laxemar-Simpevarp regional model area. Figure 6-22 shows the distribution of regolith depths in the central part of the model area. The result clearly reflects the overall character of the area with thin layers of QD in the high topographical areas and thicker layers in the valleys. The relatively thick regolith layers in areas covered by glaciofluvial sediment and artificial fill diverge from that pattern, however. The large Tuna esker in particular is clearly recognisable in the western part of the modelled area (Figure 6-21). There are relatively few data showing the total depth of the regolith in the large valleys (e.g. from ZSMEW002A in Figure 6-2). In the regolith depth and stratigraphy model, most of the depths in these valleys are calculated from the average thickness of the deposits present in these areas. Results from drilling indicate, however, that the regolith

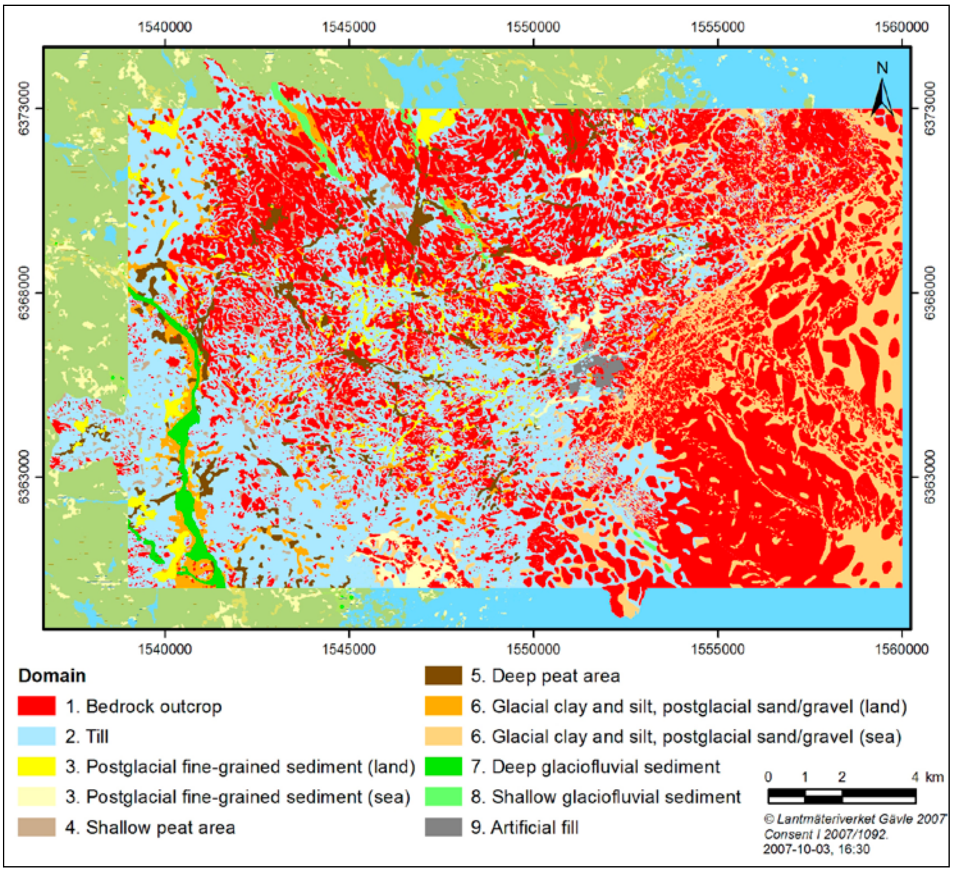


Figure 6-20. The model area classified in nine types of domains, which were used in the regolith depth and stratigraphy model.

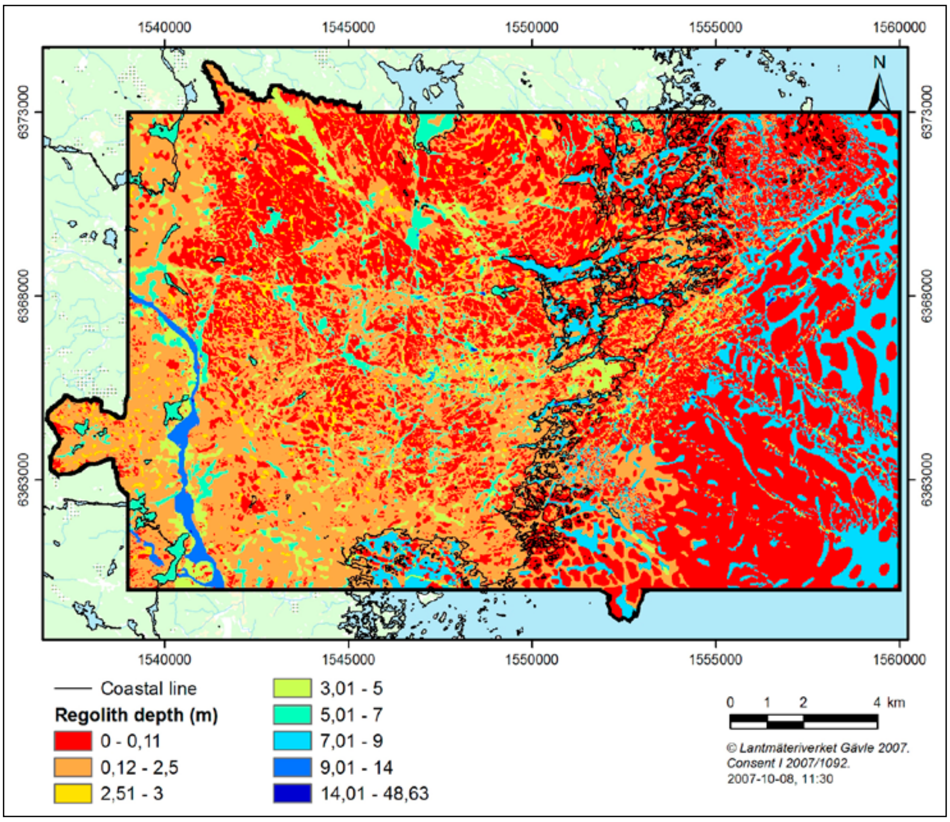


Figure 6-21. The modelled distribution of total regolith depths in the Laxemar-Simpevarp area.

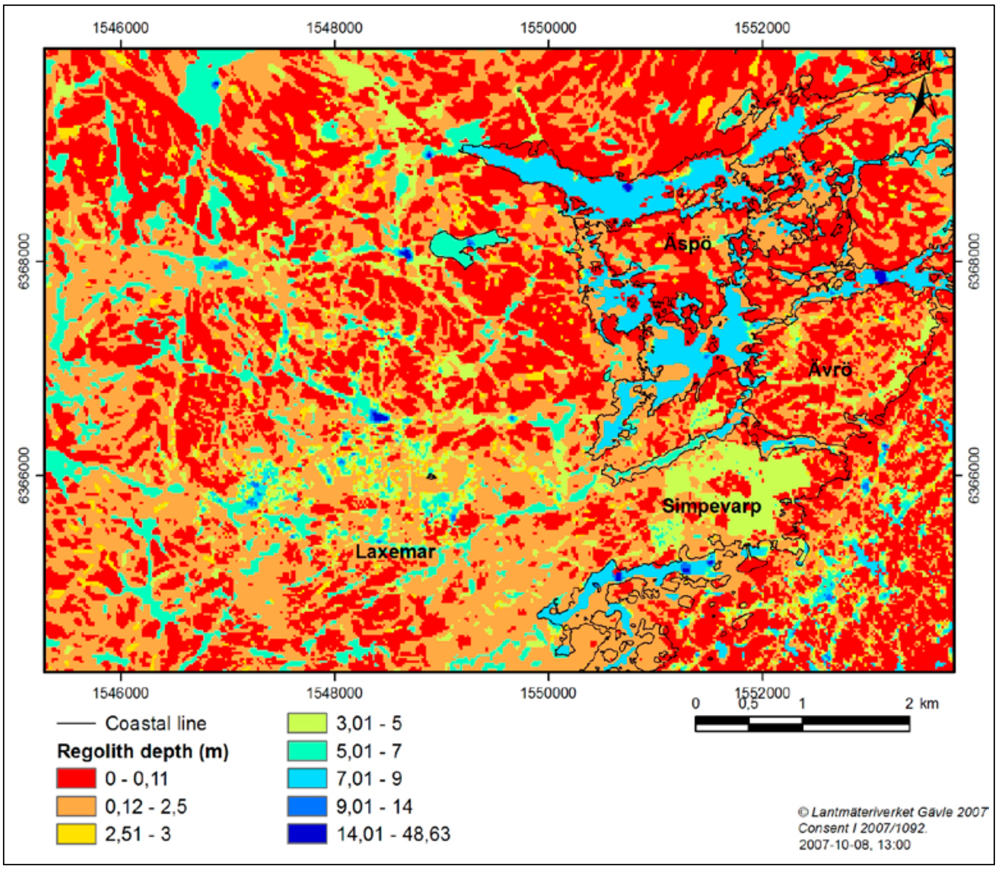


Figure 6-22. *The modelled distribution of total regolith depths in the central part of the Laxemar-Simpevarp regional model area.*

depth in the large valleys is generally greater than the average values used in the model. It is therefore possible that the total depth of the regolith in the large valleys is generally greater than shown in the model. The uncertainties in the regolith depth and stratigraphy model are further discussed in Chapter 8 and in /Nyman et al. 2008/.

The regolith depth and stratigraphy model can be used for obtaining data from observation points, e.g. boreholes, and permits stratigraphical profiles to be extracted. Four such profiles are presented in Figures 6-24, 6-25, 6-26 and 6-27. Figure 6-23 shows the geographical position of theses profiles. The profiles also show all observation points that fall within 20 metres of the line. This means that observation points situated up to 10 metres from the line in either direction will be included. In some illustrated profiles, the elevations of observation points and depths of geological units may therefore differ from the modelled layers displayed in the profiles. The total regolith depth and stratigraphy model is mainly produced by the use of the average thickness of the different deposits. That is also reflected by the often smooth thickness of the Z-layers shown in the profiles. The large glaciofluvial deposit in the western part of the model area, the Tuna esker, is an example of a deposit that has been modelled by the use of a small data set. The thickness of the esker shown in the profile (Figure 6-27) is therefore the calculated average thickness of the Tuna esker (in the model area). As a consequence, the topography of the modelled bedrock surface follows that of the overlying ground surface. The true bedrock surface probably has a deviating morphology.

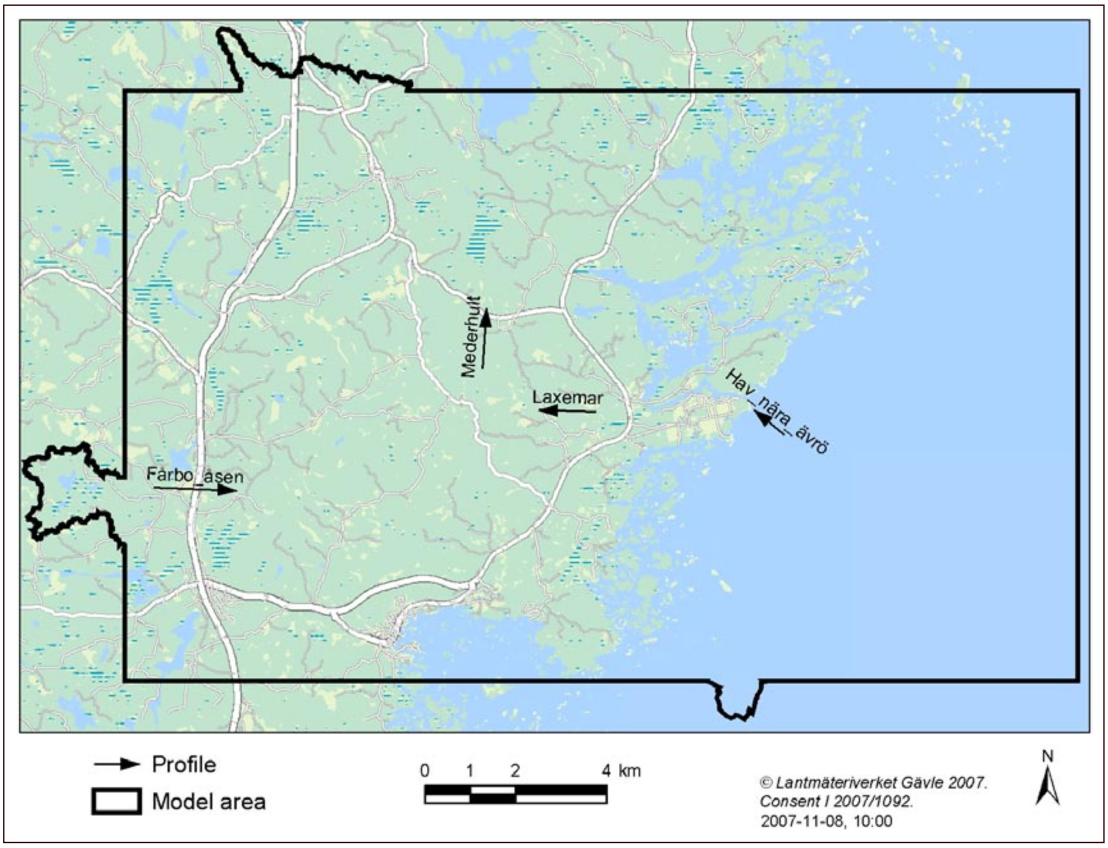


Figure 6-23. *The geographical distribution of the profiles that are shown below.*

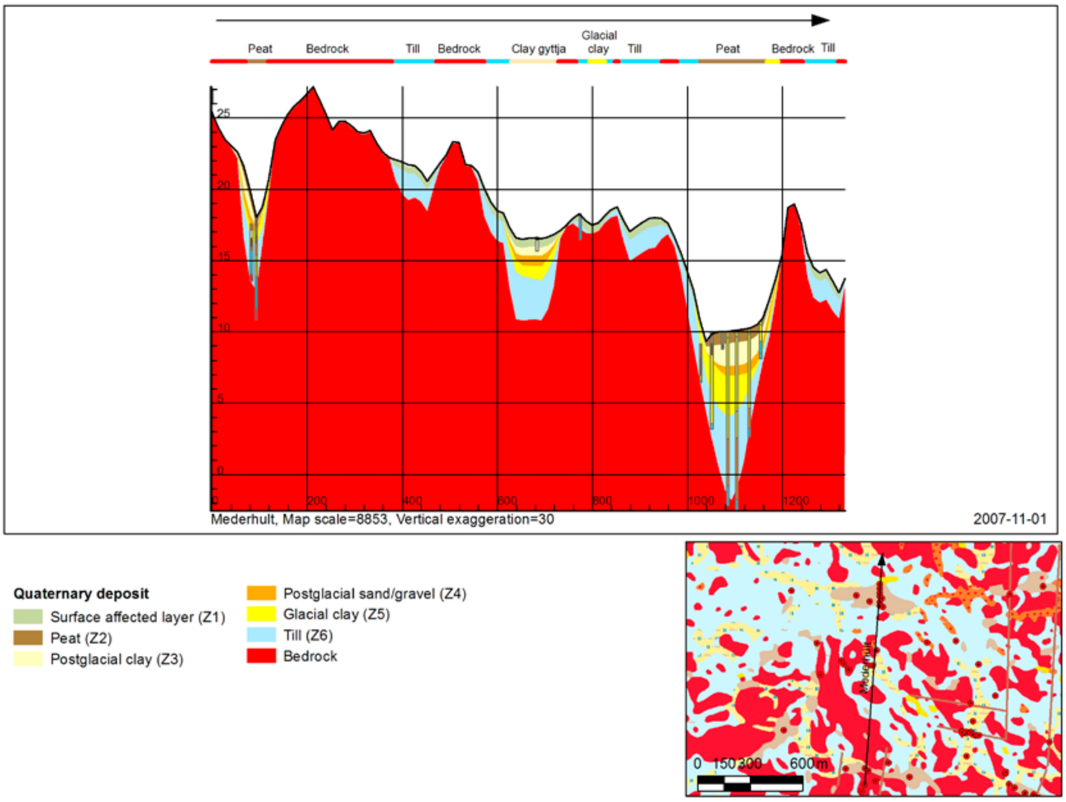


Figure 6-24. *The profile shows the total depth and stratigraphy of the regolith in a north-south profile close to Mederhult. The valley in the right part of the profile is one of the largest lineaments in the model area (ZSMEW002A in Figure 6-2).*

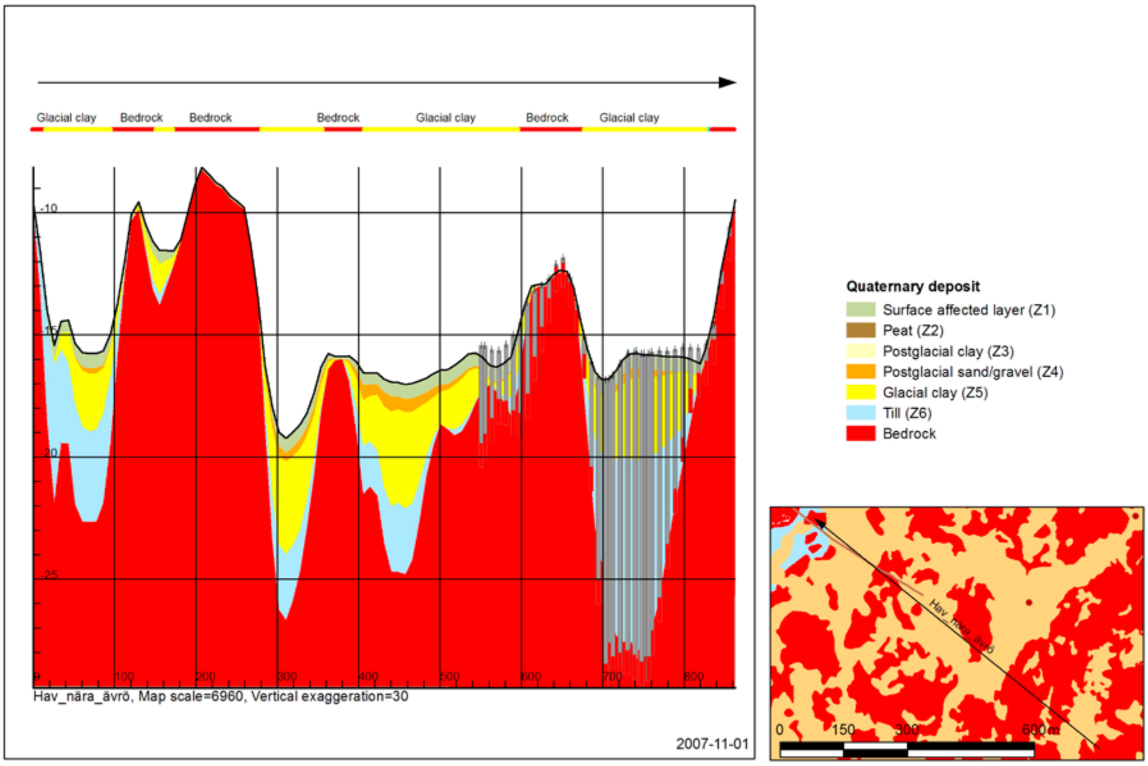


Figure 6-25. *The profile shows the depth and stratigraphy of the regolith on the sea floor southeast of the island of Ävrö.*

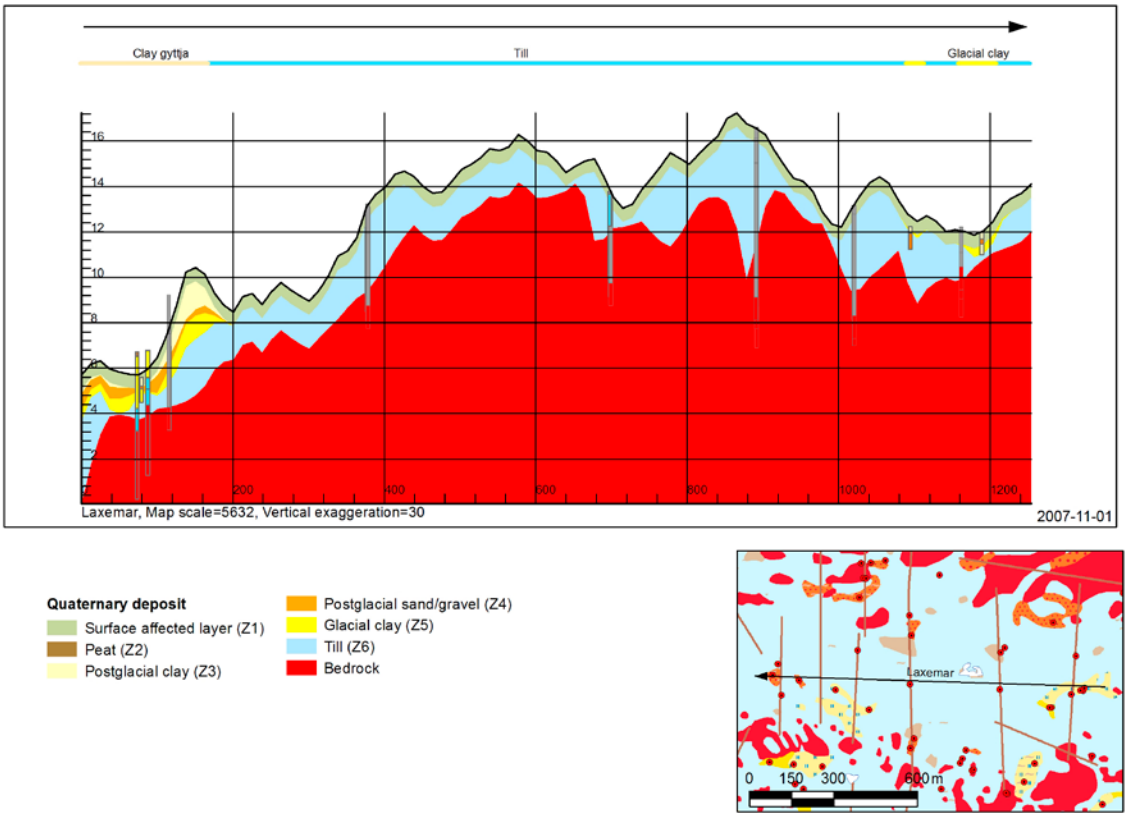


Figure 6-26. *The profile shows the total depth and stratigraphy of the regolith close to Stora Laxemar. That area is characterised by a relatively thick till cover. The results indicate that the morphology of the ground surface differs from that of the underlying bedrock.*

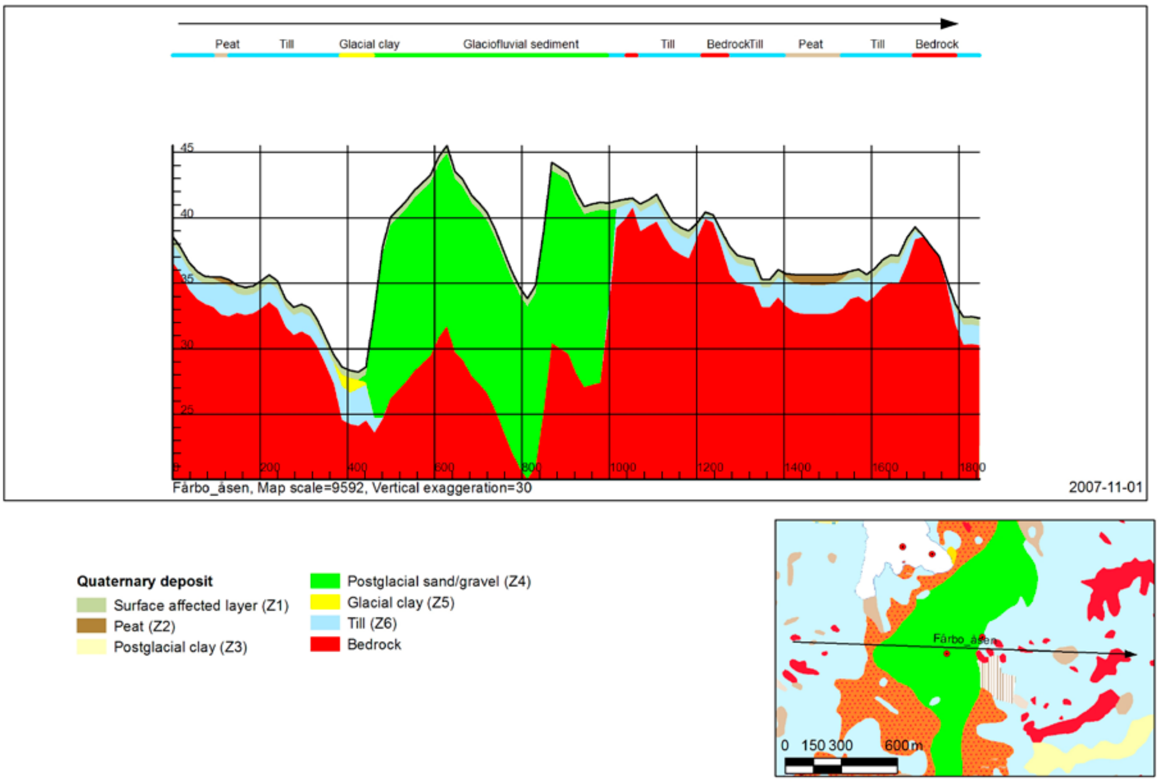


Figure 6-27. The profile shows the total depth and stratigraphy of the regolith across the glaciofluvial esker, Tunåsen, north of the village of Fårbo.

6.4 Physical and chemical properties

6.4.1 Physical properties

The results reported here include grain size distributions, bulk density, porosity, water content etc of the most common QD and soils.

Some of the physical properties are summarised in Table 6-11. The wet bulk density and porosity have been calculated from the carbon and water contents. It was assumed that water and organic matter have a density of 1 g/cm^3 and that the mineral particles have a density of 2.65 g/cm^3 /Almén and Talme 1975/. The organic content was calculated as the carbon content * 1.7, based on the van Bemmelen factor /Jackson 1958/. The organic content and water content of the top sediments in the archipelago were studied by /Fredriksson 2004/. The organic top sediments were sampled at sites where accumulation of sediment occurs. The inorganic sediments, mostly sand and gravel, represent bottoms dominated by erosion or transport of sediment. There are unfortunately no available data showing the bulk density, porosity and water content of the till and glaciofluvial sediments. The approximate porosity of these deposits has, however, been calculated from results obtained by /Lundin et al. 2005/ with the Viro method (Table 6-13). These measurements were made in the uppermost part of the QD representing layer Z1 in the regolith depth and stratigraphy model. Values representing the deeper regolith of till and sand/gravel have been taken from the literature and are presented in Table 6-11. The literature values representing sand and gravel are assumed to be representative of the postglacial and glacial sand/gravel deposits in the model area.

The grain size distribution of QD (material < 20 mm) has been determined in several studies /e.g. Nilsson 2004, Bergman et al. 2005, Rudmark et al. 2005/. The results of grain size analyses of the most common QD are summarised in Table 6-12 and in Appendix 5 and Appendix 6. Most till samples are totally dominated by sand and gravel and have clay contents lower than 5%. One till sample has a clay content of 12% (PSM005406). This clayey till was found below

Table 6-11. The average physical properties of the Quaternary deposits. The properties for till and sand/gravel were taken from the literature and were not obtained from the site investigation. The bulk density refers to the calculated density of water-saturated material.

	N	Water content (% by weight)	Porosity (% by volume)	Wet bulk density (kg/m³)	Layer in the QD depth model	Reference
Till			10–25	2,100–2,400	Z6	Almén and Talme 1975
Glacial clay	11	51.9 ± 8.3	73.5 ± 6.6	1,430 ± 105	Z5	Nilsson 2004, Sohlenius et al. 2006
Clay gyttja	42	83.4 ± 5.4	90.0 ± 3.4	1,081 ± 33	Z3	Nilsson 2004
Peat	18		92.6 ± 3.0	100 ± 57*	Z2	Lundin et al. 2005
Peat	2	91.5	92.0	1,005	Z2	Nilsson 2004
Top sediment (clay gyttja)	58	90.8 ± 1.6	94.7 ± 0.9	1,043 ± 9	Z1**	Fredriksson 2004
Sand/gravel			15–50	1,800–2,300	Z4***	Almén and Talme 1975
Top sediment (sand and gravel)	22	24.8 ± 14.7	43.4 ± 17.3	1,914 ± 293	Z1+	Fredriksson 2004

* Dry bulk density.
** In areas with clay gyttja.
*** In areas with peat, sand/gravel or clay.
+ At sea floor areas with sand/gravel.

Table 6-12. The average grain size distribution of material < 20 mm in Quaternary deposits. * The sand samples are of both glacial and postglacial origin. **Sand and gravel that were classified as till in the field but have a grain size distribution equal to water-laid sediments. All these well sorted "till" samples were obtained from boreholes in the valleys. Values are presented as the percent by dry weight values.

Quaternary deposit	N	Layer in the QD depth model	Gravel (%)	Sand (%)	Silt content (%)	Clay content (%)	d60/d10
Average gravelly till	31	Z6	47.7 ± 10.5	40.1 ± 10.4	9.4 ± 3.6	2.8 ± 1.2	102 ± 134
Average sandy till	16	Z6	27.7 ± 9.2	46.5 ± 11.8	21.5 ± 14.3	4.3 ± 2.5	69.7 ± 59.7
Average till	48	Z6	40.1 ± 14.7	41.9 ± 11.3	14.3 ± 11.6	3.7 ± 3.1	133 ± 170
Average clay gyttja	61	Z3	0.0 ± 0.1	20.9 ± 11.6	46.4 ± 11.6	32.7 ± 12.5	–
Average glacial clay	18	Z5	0.5 ± 1.2	9.0 ± 7.6	31.1 ± 9.0	59.4 ± 12.3	–
*Average sand	9	Z4	17.4 ± 22.1	79.5 ± 22.0	2.3 ± 1.5	0.8 ± 1.1	–
**Sand and gravel	9	Z6	55.6 ± 15.4	41.9 ± 14.2	2.6 ± 2.0	0	16.7 ± 5.4

the sandy till and may have been deposited during an older phase of the latest glaciation /Rudmark et al. 2005/. The coefficient d60/d10 has been calculated to demonstrate the degree of sorting. The deposit is poorly sorted with respect to grain size if d60/d10 is above 15. Most of the till samples have a d60/d10 well above 15 (see Appendix 5).

The grain size distribution of glacial and postglacial sand is presented as one value in Table 6-12. There are too few samples to conclude whether there is any significant difference in grain size distribution between glacial and postglacial sand/gravel.

At several sites in the valleys the till below the clay is quite well sorted /Morosini et al. 2007/. These well-sorted deposits have been classified as till in the field but are shown as sand and gravel in Table 6-12. The well sorted till deposits almost completely lack silt and clay and thus probably have a considerably higher hydraulic conductivity compared with the till in general. The well sorted till material is present in samples from several boreholes and it is therefore believed that the till deposits overlying the bedrock in the valleys is often better sorted than the till in general. However, the possibility cannot be excluded that the grain size composition of the well sorted till has been changed during the sampling procedure.

Table 6-13. Results from the Viro methods obtained by /Lundin et al. 2005/. These measurements were all carried out in the uppermost part of the QD representing Z1 in the regolith depth and stratigraphy model /Nyman et al. 2008/.

Depth cm	QD	Stones & boulders, % by volume	Soil material < 20 mm, % by volume	Porosity, % by volume
10–20	Till	54	18	28
20–30	”	54	19	26
55–65	”	54	23	23
10–20	Till	45	27	28
20–30	”	45	24	31
55–65	”	45	29	26
10–20	Glaciofluvial sediments	58	22	21
20–30	”	58	24	18
55–65	”	58	25	17
10–20	Glaciofluvial sediments	59	16	25
20–30	”	59	29	12
55–65	”	59	25	16

There are no reports dealing with the properties of the artificial fill in the area. Most artificial fill is material from the building of the nuclear power plant. That material has probably a coarse grain size composition and a chemical and mineralogical composition similar to the local bedrock.

The results from measurements of the specific surface are shown in Table 6-14. /Maxe 2003/ has measured the specific surface on samples from different sites distributed all over Sweden. A comparison with the results presented here shows that the till and clay samples have a specific surface similar to equivalent deposits in other parts of Sweden. The values are, however, lower than the average Swedish values for these deposits /cf Maxe 2003/. The till is rather coarse-grained in the investigated area, which may explain the relatively low specific surface of the till. The postglacial sand (Table 6-14) has a much smaller specific surface than sand samples studied by /Maxe 2003/. The reason for that difference is not known.

Table 6-14. Results from measurements of the specific surface. Each sample was analysed two times (A and B).

ID-code	Sample	Surface m^2/g (A)	Surface m^2/g (B)	Surface m^2/g (average)
ASM000124	Clay gyttja'*	11.17	13.66	12.42
PSM001477	Clay gyttja	10.28	10.07	10.18
ASM000125	Clay gyttja	19.60	19.61	19.61
PSM001472	Clay gyttja	19.32	18.99	19.16
PSM001477	Postglacial Sand	0.136	0.163	0.150
PSM001477	Clay	27.03	27.21	27.12
ASM000126	Till	1.13	1.22	1.18
PSM001472	Till	1.19	0.82	1.01

* This sample was classified as peat but chemical analyses suggest that the sample represents some gyttja sediment.

6.4.2 Chemical and mineralogical properties

Chemistry of Quaternary deposits

Results of studies of the chemical and mineralogical composition of the most commonly occurring QD in the Laxemar-Simpevarp area are discussed in this chapter. The chemical properties of the surface system have also been discussed by /Tröjbom and Söderbäck 2006/ and /Tröjbom et al. 2008/. The chemical composition of the QD roughly reflects the composition of the local or neighbouring bedrock. The primary rock composition may, however, be partly changed due to chemical processes taking place before and after the deposition of the QD's. The data from the Laxemar-Simpevarp area are compared with data from other parts of Sweden. The chemical composition of the QD in the Laxemar-Simpevarp area is presented in Appendix 8.

Till

The chemical composition of 20 till samples from the Laxemar-Simpevarp area was analysed by SGU /Andersson and Nilsson 1992/ before the start of the site investigation. The data from /Andersson and Nilsson 1992/ is presented in /SGU 2006/. SGU's data was collected in a national mapping programme. That makes it possible to compare the results from the Laxemar-Simpevarp area with results from other parts of Sweden.

/Lindroos 2004/ discusses the potential for ore industry in the Laxemar-Simpevarp area. He re-analysed some of the samples earlier analysed by SGU /Andersson and Nilsson 1992/ together with samples collected during the mapping of QD /Rudmark et al. 2005/. There are no great differences between the results from the re-analysed samples and the results from the older investigation by SGU /SGU 2006/. The chemical composition of till samples from machine-cut trenches in the Laxemar subarea was analysed by /Sohlenius et al. 2006a/. The results of all the chemical analyses of till are compiled in Table 6-15, Table 6-16, Table 6-17, Table 6-18

Table 6-15. Element analyses on till samples from the Laxemar-Simpevarp regional model area and from the national geochemical survey conducted by SGU /SGU 2006/. The samples were digested with Aqua Regia and subsequently analysed by ICP-AES. There are no minimum values in the data from the Swedish database. That is because the lowest values were below the detection limit for the ICP-AES technique. N=number of analysed samples. The analyses were performed on the grain size fraction < 0.063 mm. The values represent the concentration in samples dried at 105°C.

			Till – Laxemar-Simpevarp (ICP-AES)					Till – Swedish reference (ICP-AES)			
	Element	Unit	N	Mean	Std. dev	Max	Min	N	Mean	Std. dev	Max
Al_2O_3	Aluminium	%	20	1.9	0.8	3.8	0.8	15843	2.1	0.95	12.6
CaO	Calcium	%	20	0.52	0.28	1.23	0.11	15842	0.49	1.25	53.6
Fe_2O_3	Iron	%	20	2.7	1.1	4.2	0.5	15842	2.47	1.0	13.3
K_2O	Potassium	%	20	0.14	0.08	0.3	0.04	15841	0.16	0.12	1.56
MgO	Magnesium	%	20	0.79	0.48	2.47	0.10	15844	0.58	0.33	6.8
MnO	Manganese	%	20	0.038	0.018	0.079	0.005	15838	0.036	0.030	1.05
BaO	Barium	mg/kg	20	41	16	75	13	15832	47.6	33.0	1,535
Be	Beryllium	mg/kg	19	0.7	0.5	2.5	0.2	13286	0.52	0.27	3.9
Co	Cobalt	mg/kg	19	6.4	2.8	15.7	3.3	15158	5.2	3.1	61.8
Cu	Copper	mg/kg	20	11.9	13.3	66.7	2.5	15834	14.1	10.5	229.1
La	Lanthanum	mg/kg	20	45.8	31.7	134	9	15831	29.1	13.8	337.5
Li	Lithium	mg/kg	19	15.1	6.3	29.9	5.6	15060	12.9	8.4	98.1
Ni	Nickel	mg/kg	19	8.3	5.9	29.4	2.5	15619	11.8	8.5	178.8
Pb	Lead	mg/kg	19	41.6	74.6	340	9	12182	12.6	11.3	423
Sr	Strontium	mg/kg	20	22.9	2.5	48	8	15837	13.5	12.6	462
Zn	Zinc	mg/kg	20	47.8	34.6	180	7	15828	38.7	30.8	2197

Table 6-16. Element analyses on till samples from the Laxemar-Simpevarp regional model area /Lindroos 2004/. The analyses were performed on the grain size fraction < 0.063 mm. The values represent the concentration in samples dried at 105°C. Seven of the till samples were taken during the mapping of QD /Rudmark et al. 2005/. Six of the samples taken during SGU's geochemical mapping survey /SGU 2006/ were re-analysed. The samples were digested in Aqua Regia and subsequently analysed by ICP-AES. The correlation between the old and the new analyses were surprisingly good /cf Lindroos 2004/.

			Till – Laxemar-Simpevarp (ICP-AES)				
	Element	**Unit**	**N**	**Mean**	**Std. dev**	**Max**	**Min**
Al_2O_3	Aluminium	%	15	1.98	0.66	3.36	0.96
CaO	Calcium	%	15	0.63	0.17	0.96	0.42
Fe_2O_3	Iron	%	15	3.30	0.84	5.39	1.53
K_2O	Potassium	%	15	0.20	0.10	0.42	0.06
MgO	Magnesium	%	15	0.89	0.31	1.51	0.40
MnO	Manganese	%	15	0.038	0.011	0.057	0.019
Na_2O	Sodium	%	15	0.013	0.003	0.020	0.008
P_2O_5	Phosphorus	%	15	0.27	0.07	0.40	0.15
S	Sulphur	%	15	0.021	0.028	0.12	0.01
TiO_2	Titanium	%	15	0.27	0.05	0.38	0.22
Ag	Silver	ppb	15	27.9	15.3	76.0	11.0
As	Arsenic	mg/kg	15	1.57	0.85	3.80	0.20
Au	Gold	ppb	15	0.60	0.72	2.9	0.1
B	Boron	mg/kg	15	2.27	1.10	4.0	1.0
Ba	Barium	mg/kg	15	46.9	25.1	92.5	14.9
Bi	Bismuth	mg/kg	15	0.25	0.17	0.70	0.11
Cd	Cadmium	mg/kg	15	0.063	0.018	0.10	0.04
Co	Cobalt	mg/kg	15	6.8	2.2	9.9	2.8
Cr	Chromium	mg/kg	15	20.6	8.2	35.8	9.1
Cu	Copper	mg/kg	15	18.0	19.2	76.8	3.4
Ga	Gallium	mg/kg	15	5.3	1.6	9.1	3.2
Hg	Mercury	ppb	15	15	10	40	5
La	Lanthanum	mg/kg	15	51.5	29.9	131.5	25.0
Mo	Molybdenum	mg/kg	15	0.84	0.87	3.85	0.18
Ni	Nickel	mg/kg	15	9.4	4.6	18.6	3.4
Pb	Lead	mg/kg	15	20.5	18.6	76.2	8.3
Sb	Antimony	mg/kg	15	0.11	0.06	0.32	0.07
Sc	Scandium	mg/kg	15	3.1	1.2	5.9	1.8
Se	Selenium	mg/kg	15	0.13	0.08	0.30	0.05
Sr	Strontium	mg/kg	15	29.2	5.7	37.5	21.3
Te	Tellurium	mg/kg	15	0.02	0.02	0.08	0.01
Th	Thorium	mg/kg	15	16.4	7.1	39.2	7.6
Tl	Thallium	mg/kg	15	0.17	0.08	0.33	0.05
U	Uranium	mg/kg	15	3.5	2.3	11.6	2.0
V	Vanadium	mg/kg	15	43	11	59	20
W	Tungsten	mg/kg	15	0.52	0.36	1.7	0.2
Zn	Zinc	mg/kg	15	49.1	12.9	71.9	26.5

Table 6-17. Element analyses on till samples from the Laxemar-Simpevarp regional model area and from the national geochemical survey conducted by SGU /SGU 2006/. The samples were analysed by XRF and the values represent the total concentrations in the samples. The analyses were performed on the grain size fraction < 0.063 mm. The values represent the concentration in samples dried at 105°C.

			Till – Laxemar-Simpevarp (XRF)					Till – Swedish reference (XRF)				
	Element	**Unit**	**N**	**Mean**	**Std.dev**	**Max**	**Min**	**N**	**Mean**	**Std. dev**	**Max**	**min**
Al_2O_3	Aluminium	%	20	13.65	1.19	15.8	11.5	26343	13.59	1.75	33.1	1.3
BaO	Barium	%	20	0.075	0.01	0.088	0.057	26343	0.061	0.01	0.85	0.02
CaO	Calcium	%	20	1.75	0.38	2.55	0.96	26343	2.26	1.65	54.98	0.09
Fe_2O_3	Iron	%	20	3.62	0.97	5.63	1.92	26343	3.86	1.25	15.3	0.49
K_2O	Potassium	%	20	3.59	0.32	4.12	2.79	26343	2.88	0.47	6.7	0.37
MgO	Magnesium	%	20	1.36	0.61	3.20	0.47	26343	1.38	0.58	7.89	0.15
MnO	Manganese	%	20	0.053	0.018	0.093	0.032	26343	0.063	0.030	1.124	0.009
Na_2O	Sodium	%	20	2.48	0.49	3.29	1.66	26343	2.68	0.71	5.23	0.09
P_2O_5	Phosphorus	%	20	0.255	0.111	0.437	0.062	26343	0.233	0.081	1.97	0.01
SiO_2	Silicon	%	20	72.0	2.3	75.8	66.7	26343	72.1	3.8	89.2	41.1
TiO_2	Titanium	%	20	0.936	0.423	2.596	0.58	26343	0.739	0.181	2.596	0.069
Co	Cobalt	mg/kg	20	16.8	5.6	31	7	26335	20.8	8.6	95	–
Cr	Chromium	mg/kg	20	31.7	12.7	58	15	26343	52.2	27.1	604	6
Cu	Copper	mg/kg	20	13.9	16.1	80	2	26246	16.9	13.6	532	–
Ni	Nickel	mg/kg	19	11.2	6.3	32	–	26112	18.8	11.5	204	–
Pb	Lead	mg/kg	20	57.6	73.4	357	26	26139	24.2	13.5	992	–
Rb	Rubidium	mg/kg	20	107.9	42.4	257	66	26342	88.7	24.0	408	16
S	Sulphur	mg/kg	–	–	–	–	–	26099	205	262	11703	–
Sr	Strontium	mg/kg	20	253	56	342	129	26343	175	56	706	21
V	Vanadium	mg/kg	20	62.3	14.0	89	35	26263	63.6	28.7	1562	–
Zn	Zinc	mg/kg	20	59.2	37.2	201	18	26343	54.4	31.4	2165	8
Zr	Zirconium	mg/kg	20	586	122	833	423	26343	481	149	2243	56

and in Appendix 8. Results from the Laxemar-Simpevarp area were quantitatively compared with SGU's results from till analyses in other parts of Sweden (Table 6-15 and Table 6-17) and qualitatively compared with studies of the chemical composition of till in other forested areas of Sweden /Melkerud et al. 1992/ (material < 2 mm).

The data shows that the chemical composition of the till in the Laxemar-Simpevarp area is relatively normal in a Swedish context. Most elements analysed after dissolution with Aqua Regia show values close to the average values for Swedish till (Table 6-15). Results from the XRF analyses also show that the content of Si, Al, Fe, P Mn, Mg and Na are close to the average contents of till in Sweden (Table 6-17). The contents of some elements differ, however, from the average Swedish values. The content of potassium (K) is somewhat higher in the Laxemar-Simpevarp area compared with other parts of Sweden (Table 6-17). The results presented by /Melkerud et al. 1992/ also suggest that the potassium content of the till is relatively high in the area. The reason for this is not understood, since the K content of the bedrock is not higher than in other areas. The potassium may originate from the Götemar granite north of the Laxemar-Simpevarp area. Ti is slightly enriched in till from the Laxemar-Simpevarp area, and it is worth noticing that the highest content of Ti in the whole of Sweden was recorded in the Laxemar-Simpevarp area (more than 25,000 samples determined with XRF by SGU; Table 6-17). High contents of illmenite (Ti-Fe oxide) have been recorded in diabase from the Laxemar-Simpevarp area (Carl-Henrik Wahlgren SGU oral comm). That may explain the high Ti content in some till samples. The contents of Cr and Ca in till are lower in the Laxemar-Simpevarp area than in the rest of Sweden.

Table 6-18. Analyses of eight till samples from the Laxemar-Simpevarp regional model area /Sohlenius et al. 2006a, Lundin et al. 2007/. For analyses of As, Cd, Cu, Co, Ni, Pb, and S the samples were digested in HNO_3 and subsequently analysed by ICP-MS (Marked with * in the table). The other elements are presented as the total concentrations of each element. Elements with results below the detection limit are not presented. The values represent the concentration in samples dried at 105°C. All data from the eight samples are shown in Appendix 8.

	Element	Unit	N	Mean	Std.dev	Max	Min
Al_2O_3	Aluminium	%	8	14.0	0.59	14.6	12.9
CaO	Calcium	%	8	2.09	0.52	2.77	1.13
Fe_2O_3	Iron	%	8	4.79	1.64	7.65	3.22
K_2O	Potassium	%	8	4.15	0.46	5.00	3.65
MgO	Magnesium	%	8	1.28	0.49	2.31	0.78
MnO	Manganese	%	8	0.070	0.017	0.1	0.050
Na_2O	Sodium	%	8	3.58	0.20	3.77	3.27
P_2O_5	Phosphorus	%	8	0.174	0.049	0.287	0.137
SiO_2	Silicon	%	8	69.1	1.99	71.6	65.2
TiO_2	Titanium	%	8	0.474	0.112	0.710	0.360
*As	Arsenic	mg/kg	8	0.97	0.22	1.35	0.71
Ba	Barium	mg/kg	8	952	80	1100	840
Be	Beryllium	mg/kg	8	1.80	1.03	3.12	0.66
Br	Bromine	mg/kg	6	0.91	0.36	1.54	0.64
*Cd	Cadmium	mg/kg	8	0.029	0.008	0.040	0.018
Ce	Cerium	mg/kg	8	67	19.6	102	41.6
Cl	Chlorine	mg/kg	8	63.6	11.0	77.8	51.1
*Co	Cobalt	mg/kg	8	7.29	2.16	11.80	4.9
Cs	Caesium	mg/kg	8	2.02	0.88	3.46	0.56
Cr	Chromium	mg/kg	8	51.1	21.6	88.8	28.3
*Cu	Copper	mg/kg	8	13.4	4.8	20.0	8.3
Dy	Dysprosium	mg/kg	8	2.50	0.81	3.89	1.64
Er	Erbium	mg/kg	8	1.44	0.44	2.29	0.99
Eu	Europium	mg/kg	8	0.77	0.29	1.30	0.42
Ga	Gallium	mg/kg	8	13.2	2.1	16.4	10.7
Gd	Gadolinium	mg/kg	8	2.59	1.00	4.50	1.42
Hf	Hafnium	mg/kg	8	5.1	1.6	7.71	3.34
Ho	Holmium	mg/kg	8	0.52	0.15	0.77	0.36
La	Lanthanum	mg/kg	8	31.8	8.4	45.7	20.1
Li	Lithium	mg/kg	8	21.2	7.5	35.2	12.8
Lu	Lutetium	mg/kg	8	0.25	0.07	0.37	0.17
Mo	Molybdenum	mg/kg	8	2.1	2.2	6.5	0.76
Nb	Niobium	mg/kg	8	9.7	1.92	13.4	7.05
Nd	Neodymium	mg/kg	8	28.3	6.37	38.8	20.1
Ni	Nickel	mg/kg	8	16.6	11.6	43.2	8.1
*Pb	Lead	mg/kg	8	9.7	3.97	16.2	6.71
Pr	Praseodymium	mg/kg	8	7.09	1.83	9.70	4.72
Rb	Rubidium	mg/kg	8	116	16.1	140	93.8
*S	Sulphur	mg/kg	8	167	135	409	34.7
Sc	Scandium	mg/kg	8	5.93	1.29	8.73	4.56
Sm	Samarium	mg/kg	8	4.2	1.0	5.80	2.73
Sn	Tin	mg/kg	8	2.1	2.2	6.98	0.83
Sr	Strontium	mg/kg	8	464	82	554	354
Ta	Tantalum	mg/kg	8	0.86	0.19	1.20	0.62
Tb	Terbium	mg/kg	8	0.49	0.11	0.71	0.36
Th	Thorium	mg/kg	8	10.9	2.92	17.3	8.53
Tl	Thallium	mg/kg	8	0.27	0.19	0.59	0.062
Tm	Thulium	mg/kg	8	0.22	0.07	0.34	0.13
U	Uranium	mg/kg	8	2.94	1.10	5.03	1.94
V	Vanadium	mg/kg	8	51.6	13.2	73.9	33.7
W	Tungsten	mg/kg	8	1.94	0.84	3.28	1.05
Y	Yttrium	mg/kg	8	17.6	2.91	21.3	14.1
Yb	Ytterbium	mg/kg	8	1.61	0.37	2.26	1.17
Zn	Zinc	mg/kg	8	51.9	14.2	76.4	33.8
Zr	Zirconium	mg/kg	8	201	37.3	254	152

The study by /Lindroos 2004/ shows that the trace metal contents are low to moderate in the till in the Laxemar-Simpevarp area and that the gold content is very low (Table 6-15 and Table 6-16). The content of lead (Pb) is, however, approximately twice as high as the average for till in Sweden. The samples with the highest Pb content come from the areas round the Götemar granite, and it is therefore concluded /Lindroos 2004/ that the Pb anomalies are related to that type of bedrock. There is also a Cu anomaly in the same area which, according to /Lindroos 2004/, is related to an east-west striking "swarm" of dioritic-gabbroic outcrops. /Lindroos 2004/ also concludes that it is highly unlikely that there will be any opening of mines in the Laxemar-Simpevarp area, although some elements show relatively high contents in the local bedrock as recorded in the till samples.

One aim of the analyses of till was to verify if the chemical and mineralogical composition of the till reflects that of the bedrock /Wahlgren et al. 2005/. The results show that the till has a similar chemical composition to that of the bedrock. There are, however, some differences. The contents of e.g. Fe, Mg, Na and Ca are higher in the bedrock than in the till, whereas the bedrock contents of e.g. Si and Ti are lower (compare Table 6-17 with Table 6-19). The reason for the differences between the chemical composition of till and bedrock is probably that chemical weathering has altered the original chemical composition of the parent till material. Iron and Ca are common in minerals, which are more sensitive to weathering than Si-rich minerals, such as quartz. /Bergman and Sohlenius 2007/ have shown that most of the boulders and gravel in the till originate from the local bedrock, which support the assumption that the chemical composition of the till reflects that of the local bedrock.

Sand

The chemical composition of sand was analysed in eight samples (Table 6-22 and Appendix 8). These samples were taken both from glacial (2 samples) and postglacial deposits. The composition of the sand is similar to that of the till (Table 6-18) and is therefore interpreted as reflecting the composition of the local bedrock. Too few samples were analysed to conclude if there is any significant difference between postglacial and glacial sand.

Table 6-19. The average total chemical composition of 35 samples from the bedrock /from Wahlgren et al. 2005/.

Element		Element	
SiO_2	62.9%	Ga	26.8 mg/kg
Al_2O_3	15.9%	Hf	5.29 mg/kg
CaO	3.73%	Nb	9.88 mg/kg
Fe_2O_3	5.31%	Rb	101 mg/kg
K_2O	3.76%	Sc	8.87 mg/kg
MgO	2.05%	Sn	3.48 mg/kg
MnO	0.08%	Sr	877 mg/kg
Na_2O	3.80%	Ta	0.99 mg/kg
P_2O_5	0.29%	Th	9.07 mg/kg
TiO_2	0.75%	U	3.01 mg/kg
Sum	98.6%	V	75.1 mg/kg
Ba	1,290 mg/kg	Y	23.1 mg/kg
Be	2.53 mg/kg	Zn	176 mg/kg
Cr	30.2 mg/kg	Zr	240 mg/kg
Cu	39.1 mg/kg		

Clay

The chemical composition of water-laid fine-grained sediments is shown in Appendix 8. The chemical composition of the water-laid sediments may reflect the environmental conditions prevailing during sediment accumulation. However, diffusion, bioturbation and other processes taking place after accumulation may change the original composition of the sediments.

The content of Al is higher in glacial clay than in sand and till (Table 6-20 and Appendix 8). That probably reflects relatively high contents of Al-rich clay minerals in that clay. Weathering of primary bedrock minerals formed these minerals. The fine-grained clay minerals have thereafter been enriched in the clay due to the sorting effects of water. Trace element contents are generally higher in clay samples (Table 6-20 and Table 6-26) compared to till and sand. Several of the trace elements were analysed after digestion with HNO_3. That method does not digest the samples completely, and the digestion is more effective in fine-grained deposits (e.g. clay) than in more coarse-grained deposits like sand. That may explain the relatively high trace element contents in the clays compared to the more coarse-grained deposits.

The clay gyttja (Table 6-23) has a relatively high content of silicon (SiO_2) compared with other elements, which occur in high contents in the other QD (e.g Al and Ti). That is probably an effect of high contents of biogenic silica in the clay gyttja. The highest SiO_2 content was recorded in the gyttja clay from PSM007171, and microscope studies showed that the clay contains a high quantity of diatoms, which are composed of SiO_2.

The contents of Cl and Br (Bromine) are high in many of the clay gyttja samples. These sediments have partly been deposited in brackish water, which explains the high contents of these elements.

The contents of Cd, Mo and Cu are relatively high in the gyttja at profile 5 close to Mederhult (see PSM007190 in Appendix 8). That may be an effect of anoxic bottom conditions during sediment accumulation /cf Sternbeck and Sohlenius 1997/. The high content of Br in the gyttja at Profile 5 may be an effect of the brackish conditions prevailing when the gyttja was deposited

An attempt was made to compare the composition of clay gyttja and glacial clay from Laxemar-Simpevarp with the results of SGU's national mapping programme (Table 6-21). The samples analysed by SGU were analysed after digestion with HNO_3. Since most of the results in the present study represent the total content of each element, it is difficult to make a direct comparison with SGU's results. However, some of the trace elements in the present study were analysed after digestion equivalent to that of the SGU samples. The glacial clay in Laxemar-Simpevarp generally has a higher content of these trace elements compared with the SGU samples. The clay gyttja on the other hand has lower contents of many elements compared with the SGU samples. That may be explained by the high content of biogenic silica (diatoms) and organic material in the clay gyttja from Laxemar-Simpevarp diluting the contents of other elements.

Peat

All elements occur in low contents in the peat (Table 6-24), which is due to the high content of organic matter in the peat. The average composition of Swedish peat is shown on the web site of SGU (www.sgu.se). Compared with the average Swedish peat, the peat samples in the present study have lower or similar element contents. However, all analysed peat samples are taken from the same wetland, the bog Klarebäcksmossen, and it is likely that the chemical composition of the peat varies within the model area. /Lidman 2005/ has analysed radionuclides in peat and sediments from the bog Klarebäcksmossen to assess radionuclide transport during peatland development. The result indicates that uranium has been mobilised from underlying clay and accumulated in the gyttja. Radium has leached out from the gyttja, which might have happened recently. The peat has low levels of radionuclides, but the contents are clearly higher in the fen peat than in the bog peat, which may be a result of minerotrophic conditions during the fen stage.

Table 6-20. Analyses of nine glacial clay samples from the Laxemar-Simpevarp regional model area. For analyses of As, Cd, Cu, Co, Ni, Pb, and S (Marked with * in the table) the samples were digested in HNO_3 and subsequently analysed by ICP-MS /Engdahl et al. 2006, Lundin et al. 2007/. The other elements are presented as the total concentrations of each element. Elements with results below the detection limit are not presented. The values represent the concentration in samples dried at 105°C. All data from the eight samples are shown in Appendix 8.

	Element	Unit	N	Mean	Std.dev	Max	Min
Al_2O_3	Aluminium	%	9	16.3	1.2	18.3	15.0
CaO	Calcium	%	9	1.40	0.14	1.63	1.15
Fe_2O_3	Iron	%	9	7.65	2.06	12.5	5.42
K_2O	Potassium	%	9	4.33	0.25	4.79	4.04
MgO	Magnesium	%	9	2.50	0.48	3.21	1.77
MnO	Manganese	%	9	0.080	0.024	0.14	0.05
Na_2O	Sodium	%	9	1.87	0.23	2.28	1.52
P_2O_5	Phosphorus	%	9	0.19	0.02	0.23	0.17
SiO_2	Silicon	%	9	59.7	4.3	66.1	52.6
TiO_2	Titanium	%	9	0.70	0.05	0.79	0.64
C	Carbon	%	9	0.38	0.28	0.85	–
Org. C	Organic carbon	%	9	0.35	0.23	0.63	–
N	Nitrogen	g/kg	9	1.7	3.5	11.1	0.2
Org. N	Organic nitrogen	g/kg	9	1.3	2.9	9.1	–
As*	Arsenic	mg/kg	9	3.25	1.35	5.29	1.46
Ba	Barium	mg/kg	9	673	67	746	509
Be	Beryllium	mg/kg	9	2.95	0.72	3.94	1.89
Br	Bromine	mg/kg	9	5.77	13.5	40.0	–
Cd*	Cadmium	mg/kg	9	0.12	0.05	0.23	0.07
Ce	Cerium	mg/kg	9	95.8	16.7	116	72
Cl	Chlorine	g/kg	9	1.04	2.29	6.44	–
Co*	Cobalt	mg/kg	9	17.4	2.95	22.0	12.7
Cs	Caesium	mg/kg	9	7.70	1.93	10.4	5.1
Cr	Chromium	mg/kg	9	94.9	23.8	156	72.9
Cu*	Copper	mg/kg	9	27.1	2.9	30.9	21.2
Dy	Dysprosium	mg/kg	9	5.50	1.14	7.27	3.62
Er	Erbium	mg/kg	9	3.17	0.74	4.21	1.83
Eu	Europium	mg/kg	9	1.11	0.30	1.5	0.7
Ga	Gallium	mg/kg	9	25.7	20.1	73.1	9.5
Gd	Gadolinium	mg/kg	9	5.6	1.3	7.0	3.6
Hf	Hafnium	mg/kg	9	5.01	1.28	7.01	3.41
Ho	Holmium	mg/kg	9	1.09	0.22	1.43	0.77
La	Lanthanum	mg/kg	9	44.5	9.1	55.9	31.7
Li	Lithium	mg/kg	9	47.9	13.1	73.0	32.3
Lu	Lutetium	mg/kg	9	0.44	0.10	0.59	0.27
Nb	Niobium	mg/kg	9	15.3	1.44	18.0	13.5
Nd	Neodymium	mg/kg	9	42.1	7.9	52.6	29.2
Ni*	Nickel	mg/kg	9	32.1	6.6	43.3	21.8
Pb*	Lead	mg/kg	9	24.5	5.9	32.5	16.0
Pr	Praseodymium	mg/kg	9	11.0	2.1	13.6	7.7
Rb	Rubidium	mg/kg	9	166	38.0	221	123
S*	Sulphur	g/kg	9	2.96	5.10	13.2	0.07
Sc	Scandium	mg/kg	9	14.5	2.2	17.6	11.4
Sm	Samarium	mg/kg	9	7.00	1.42	9.4	4.8
Sr	Strontium	mg/kg	9	173	28	221	134
Ta	Tantalum	mg/kg	9	1.57	0.79	3.62	1.07
Tb	Terbium	mg/kg	9	0.81	0.16	0.6	1.1
Th	Thorium	mg/kg	9	17.7	1.6	19.4	14.8
Tl	Thallium	mg/kg	9	0.91	0.34	1.29	0.54
Tm	Thulium	mg/kg	9	0.49	0.13	0.67	0.26
U	Uranium	mg/kg	9	4.57	1.40	7.01	3.09
V	Vanadium	mg/kg	9	105	15	128	82
Y	Yttrium	mg/kg	9	34.1	7.4	41.5	17.3
Yb	Ytterbium	mg/kg	9	3.26	0.39	3.90	2.65
Zn	Zinc	mg/kg	9	101	15	121	84
Zr	Zirconium	mg/kg	9	219	36	276	176

Table 6-21. The average composition of Swedish gyttja sediments and glacial/postglacial fine-grained sediments. The element concentrations were measured after digestion with 7M HNO_3. The results were obtained in SGU's national mapping programme. The values represent the concentration in samples dried at 105°C.

Element	Unit	Average gyttja sediment	Average clay
Al_2O_3	%	3.3	3.2
CaO	%	0.76	0.59
Fe_2O_3	%	4.95	4.05
K_2O	%	0.55	0.491
MgO	%	1.388	1.177
MnO	%	0.0509	0.0568
Na_2O	%	0.0426	0.0337
P_2O_5	%	0.142	0.126
TiO_2	%	0.167	0.151
BaO	%	0.009	0.009
Ag	mg/kg	0.179	0.102
As	mg/kg	5.2	3.4
Be	mg/kg	1.52	0.99
Bi	mg/kg	0.4	0.198
Cd	mg/kg	0.164	0.077
Co	mg/kg	13.9	9.6
Cr	mg/kg	51	22.4
Cu	mg/kg	23.4	16.2
La	mg/kg	31.7	39.7
Li	mg/kg	34	19
Mo	mg/kg	0.91	0.36
Ni	mg/kg	31.4	16.1
Pb	mg/kg	17	12
Rb	mg/kg	53.6	44.6
S	%	0.129	–
Se	mg/kg	0.74	0.27
Sn	mg/kg	0.31	0.27
Sr	mg/kg	22.9	23.3
Th	mg/kg	14	12.3
Tl	mg/kg	0.37	0.31
U	mg/kg	4.1	2.5
V	mg/kg	55.7	40.7
W	mg/kg	0.082	0.046
Y	mg/kg	24.4	23.1
Zn	mg/kg	89.8	62.8
Zr	mg/kg	5.3	–
N		44	1054

Table 6-22. Analyses of eight sand (glacial and postglacial) samples from the Laxemar-Simpevarp regional model area. For analyses of As, Cd, Cu, Co, Ni, Pb and S (Marked with * in the table) the samples were digested in HNO_3 and subsequently analysed by ICP-MS /Engdahl et al. 2006, Lundin et al. 2007/. The other elements are presented as the total concentrations of each element. Elements with results below the detection limit are not presented. The values represent the concentration in samples dried at 105°C. All data from the eight samples are shown in Appendix 8.

	Element	Unit	N	Mean	Std.dev	Max	Min
Al_2O_3	Aluminium	%	8	13.0	2.7	15.4	7.3
CaO	Calcium	%	8	1.77	0.41	2.37	1.31
Fe_2O_3	Iron	%	8	3.56	1.24	5.19	1.72
K_2O	Potassium	%	8	3.75	0.71	4.38	2.09
MgO	Magnesium	%	8	0.93	0.55	1.77	0.40
MnO	Manganese	%	8	0.056	0.018	0.090	0.040
Na_2O	Sodium	%	8	3.40	0.53	3.85	2.22
P_2O_5	Phosphorus	%	8	0.14	0.05	0.22	0.07
SiO_2	Silicon	%	8	68.0	4.9	73.9	60.0
TiO_2	Titanium	%	8	0.38	0.12	0.53	0.20
As*	Arsenic	mg/kg	8	2.07	1.22	4.14	0.82
Ba	Barium	mg/kg	8	825	234	1040	380
Be	Beryllium	mg/kg	8	1.78	1.22	3.99	0.72
Br	Bromine	mg/kg	8	13.2	34.8	99.2	–
Cd*	Cadmium	mg/kg	8	0.17	0.35	1.02	0.02
Ce	Cerium	mg/kg	8	65.5	33.1	133	25
Cl	Chlorine	g/kg	8	1.67	4.42	12.6	0.04
Co*	Cobalt	mg/kg	8	5.69	1.95	9.3	3.5
Cs	Caesium	mg/kg	8	1.72	0.63	2.7	0.8
Cr	Chromium	mg/kg	8	41.5	17.0	69.5	14.4
Cu*	Copper	mg/kg	8	15.4	8.5	32.0	4.1
Dy	Dysprosium	mg/kg	8	2.58	1.05	3.97	1.04
Er	Erbium	mg/kg	8	1.50	0.77	2.87	0.57
Eu	Europium	mg/kg	8	0.66	0.33	1.2	0.2
Gd	Gadolinium	mg/kg	8	2.90	0.94	4.4	1.4
Hf	Hafnium	mg/kg	8	4.08	1.31	5.63	2.20
Ho	Holmium	mg/kg	8	0.53	0.21	0.87	0.27
La	Lanthanum	mg/kg	8	24.1	7.0	32.1	13.5
Li	Lithium	mg/kg	8	18.5	6.5	28.7	10.1
Lu	Lutetium	mg/kg	8	0.25	0.11	0.4	0.1
Nb	Niobium	mg/kg	8	9.4	3.2	13.6	4.8
Nd	Neodymium	mg/kg	8	23.9	7.6	31.7	11.3
Ni*	Nickel	mg/kg	8	13.4	6.7	27.7	5.5
Pb*	Lead	mg/kg	8	9.5	3.8	15.7	5.7
Pr	Praseodymium	mg/kg	8	6.49	2.68	10.8	2.4
Rb	Rubidium	mg/kg	8	118	25	146	78
S*	Sulphur	g/kg	8	2.6	4.7	13.2	0.08
Sc	Scandium	mg/kg	8	4.72	1.59	7.9	3.0
Sm	Samarium	mg/kg	8	3.62	1.27	5.5	1.5
Sr	Strontium	mg/kg	8	397	146	581	180
Ta	Tantalum	mg/kg	8	0.70	0.16	0.96	0.50
Tb	Terbium	mg/kg	8	0.44	0.18	0.7	0.2
Th	Thorium	mg/kg	8	8.40	2.28	11.80	4.98
Tl	Thallium	mg/kg	8	0.38	0.26	0.85	0.16
Tm	Thulium	mg/kg	8	0.27	0.13	0.52	0.14
U	Uranium	mg/kg	8	2.69	1.62	6.40	1.07
V	Vanadium	mg/kg	8	39.4	15.6	70.3	20.7
Y	Yttrium	mg/kg	8	18.3	6.2	26.8	8.5
Yb	Ytterbium	mg/kg	8	1.64	0.61	2.54	0.83
Zn	Zinc	mg/kg	8	44.9	26.3	90.0	20.5
Zr	Zirconium	mg/kg	8	196	90	339	89

Table 6-23. Analyses of 36 clay gyttja samples from the Laxemar-Simpevarp regional model area. For analyses of As, Cd, Cu, Co, Ni, Pb, and S (Marked with * in the table) the samples were digested in HNO_3 and subsequently analysed by ICP-MS /Engdahl et al. 2006, Lundin et al. 2007/. The other elements are presented as the total concentrations of each element. Elements with results below the detection limit are not presented. The values represent the concentration in samples dried at 105°C. All data from the 33 samples are shown in Appendix 8.

	Element	Unit	N	Mean	Std.dev	Max	Min
Al_2O_3	Aluminium	%	36	5.41	2.37	12.4	1.1
CaO	Calcium	%	36	1.13	0.35	2.0	0.3
Fe_2O_3	Iron	%	36	3.83	2.11	11.3	0.7
K_2O	Potassium	%	36	1.12	0.71	2.86	0.1
MgO	Magnesium	%	36	1.03	0.45	1.86	0.14
MnO	Manganese	%	36	0.030	0.021	0.09	0.00
Na_2O	Sodium	%	36	1.25	1.03	3.6	0.6
P_2O_5	Phosphorus	%	36	0.29	0.17	0.70	0.05
SiO_2	Silicon	%	36	44.4	13.0	77.8	5.5
TiO_2	Titanium	%	36	0.20	0.10	0.48	0.01
C	Carbon	%	36	15.2	7.5	42.0	–
Org. C	Organic carbon	%	36	11.4	6.3	38.0	–
N	Nitrogen	g/kg	36	14.3	5.6	22.9	1.3
Org. N	Organic nitrogen	g/kg	36	13.1	5.3	21.4	1.2
As	Arsenic	mg/kg	36	6.75	3.69	16.6	1.19
Ba	Barium	mg/kg	36	194	124	565	28
Be	Beryllium	mg/kg	36	3.29	2.82	9.94	0.84
Br	Bromine	mg/kg	36	70.7	74.5	246	1.48
Cd*	Cadmium	mg/kg	36	1.42	1.22	4.44	0.08
Ce	Cerium	mg/kg	36	125	79	259	22
Cl	Chlorine	g/kg	36	9.6	16.2	56.6	0
Co*	Cobalt	mg/kg	36	910.0	7.0	25.4	2.6
Cr	Chromium	mg/kg	36	42.1	28.3	153	4.2
Cu*	Copper	mg/kg	36	53.7	17.3	113	7.5
Dy	Dysprosium	mg/kg	36	6.56	3.47	13.1	1.18
Er	Erbium	mg/kg	36	3.92	2.06	8.26	0.55
Eu	Europium	mg/kg	36	1.78	1.18	3.9	0.2
Gd	Gadolinium	mg/kg	36	8.46	5.16	17.2	1.2
Ho	Holmium	mg/kg	36	1.33	0.71	2.76	0.20
La	Lanthanum	mg/kg	36	61.4	38.8	131	11
Li	Lithium	mg/kg	36	18.0	9.0	36.3	1.2
Lu	Lutetium	mg/kg	36	0.58	0.30	1.12	0.11
Nd	Neodymium	mg/kg	36	34.0	40.8	133	12
Ni*	Nickel	mg/kg	36	35.1	13.0	71.6	6.3
Pb*	Lead	mg/kg	36	18.0	12.8	46.1	5.4
Pr	Praseodymium	mg/kg	36	16.4	10.5	34.8	2.1
Rb	Rubidium	mg/kg	36	47.2	27.2	109	3.3
S*	Sulphur	g/kg	36	21.5	12.6	67.6	0.15
Sc	Scandium	mg/kg	36	6.24	2.16	11.9	1.1
Sm	Samarium	mg/kg	36	10.2	6.6	21.8	1.3
Sr	Strontium	mg/kg	36	103.7	36.4	211	55
Th	Thorium	mg/kg	36	7.74	2.56	14.9	0.9
Tl	Thallium	mg/kg	36	0.43	0.16	0.75	0.15
U	Uranium	mg/kg	36	10.4	5.2	26.6	2.2
V	Vanadium	mg/kg	36	41.3	19.0	89.6	12.8
Y	Yttrium	mg/kg	36	45.2	24.7	85.4	10.2
Yb	Ytterbium	mg/kg	36	3.80	2.04	7.51	0.63
Zn	Zinc	mg/kg	36	109	72	240	29
Zr	Zirconium	mg/kg	36	59.5	21.3	111	5

Table 6-24. Analyses of five peat samples from the Laxemar-Simpevarp regional model area. For analyses of As, Cd, Cu, Co, Ni, Pb, and S (Marked with * in the table) the samples were digested in HNO_3 and subsequently analysed by ICP-MS /Engdahl et al. 2006/. The other elements are presented as the total concentrations of each element. Elements with results below the detection limit are not presented. The values represent the concentration in samples dried at 105°C. All data from the eight samples are shown in Appendix 8.

	Element	Unit	N	Mean	Std.dev	Max	Min
Al_2O_3	Aluminium	%	5	0.52	0.31	0.8	0.1
CaO	Calcium	%	5	0.80	0.67	1.67	1.11
Fe_2O_3	Iron	%	5	0.51	0.35	0.95	0.10
K_2O	Potassium	%	5	0.018	0.018	0.05	0.01
MgO	Magnesium	%	5	0.064	0.015	0.08	0.05
MnO	Manganese	%	5	0.004	0.005	0.01	0
Na_2O	Sodium	%	5	0.018	0.018	0.05	0.01
P_2O_5	Phosphorus	%	5	0.064	0.027	0.09	0.02
SiO_2	Silicon	%	5	0.82	0.53	1.7	0.4
TiO_2	Titanium	%	5	0.012	0.008	0.02	0
C	Carbon	%	5	47.4	3.5	51.0	44.0
Org.C	Organic carbon	%	5	36.6	9.3	44.0	25.0
N	Nitrogen	g/kg	5	14.5	8.2	25.6	5.1
Org. N	Organic nitrogen	g/kg	5	13.4	8.1	24.5	4.1
As*	Arsenic	mg/kg	5	1.17	0.76	2.19	0.41
Ba	Barium	mg/kg	5	38.8	23.6	63	8
Be	Beryllium	mg/kg	5	0.23	0.15	0.39	0.06
Br	Bromine	mg/kg	5	0.66	1.56	2.35	–
Cd*	Cadmium	mg/kg	5	0.18	0.17	0.41	0.08
Ce	Cerium	mg/kg	5	20.6	17.8	42	1
Cl	Chlorine	g/kg	5	0.046	0.095	153	–
Co	Cobalt	mg/kg	5	0.96	0.32	1.3	0.5
Cr	Chromium	mg/kg	5	3.9	2.2	6.7	0.6
Cu*	Copper	mg/kg	5	6.26	4.51	13.4	1.8
Dy	Dysprosium	mg/kg	5	1.05	0.89	2.07	0.07
Er	Erbium	mg/kg	5	0.62	0.51	1.16	0.04
Eu	Europium	mg/kg	5	0.3	0.3	0.6	0.1
Ga	Gallium	mg/kg	5	2.64	1.52	4.4	0.5
Gd	Gadolinium	mg/kg	5	1.4	1.2	2.8	0.1
Hf	Hafnium	mg/kg	5	0.11	0.06	0.20	0.03
Ho	Holmium	mg/kg	5	0.22	0.18	0.43	0.01
La	Lanthanum	mg/kg	5	11.4	10.0	23.6	0.6
Li	Lithium	mg/kg	5	0.42	0.22	0.7	0.2
Lu	Lutetium	mg/kg	5	0.08	0.07	0.15	0
Mo	Molybdenum	mg/kg	5	0.9	0.6	1.8	0.1
Nb	Niobium	mg/kg	5	0.28	0.13	0.4	0.1
Nd	Neodymium	mg/kg	5	9.9	8.6	20.1	0.5
Ni*	Nickel	mg/kg	5	2.74	1.92	6.0	1.2
Pb*	Lead	mg/kg	5	6.28	9.25	22.1	0.5
Pr	Praseodymium	mg/kg	5	2.7	2.3	5.6	0.2
Rb	Rubidium	mg/kg	5	1.1	0.6	2.1	0.4
S*	Sulphur	g/kg	5	2.4	1.1	3.8	0.9
Sc	Scandium	mg/kg	5	0.68	0.45	1.1	0.1
Sm	Samarium	mg/kg	5	1.7	1.4	3.3	0.1
Sr	Strontium	mg/kg	5	32	21	56	9
Ta	Tantalum	mg/kg	5	0.014	0.009	0.02	0
Tb	Terbium	mg/kg	5	0.18	0.18	0.4	0
Th	Thorium	mg/kg	5	0.69	0.48	1.24	0.07
Tm	Thulium	mg/kg	5	0.09	0.08	0.18	0.01
U	Uranium	mg/kg	5	1.1	0.9	2.1	0.1
V	Vanadium	mg/kg	5	7.0	6.1	15.4	0.6
W	Tungsten	mg/kg	5	0.12	0.06	0.18	0.02
Y	Yttrium	mg/kg	5	6.9	5.9	13.6	0.4
Yb	Ytterbium	mg/kg	5	0.54	0.47	1.07	0.03
Zn	Zinc	mg/kg	5	7.8	9.8	25.2	1.8
Zr	Zirconium	mg/kg	5	3.8	1.6	5	1

The chemical compositions of sediments from a wetland on the island of Äspö and the floor of Borholmsfjärden were also analysed before the start of the site investigations /Landström et al. 1994, Aggeryd et al. 1996, Aggeryd et al. 1999/. The stratigraphies of these cores are equivalent to to that presented in Table 6-9. It is suggested that gravel and sand layers, separating the clay from the clay gyttja, may act as important transportation paths for elements dissolved in the pore water. The brackish water has been leached out from the clay in the wetland. It is therefore suggested that clay deposited in brackish water may act as an important source of salinity in the groundwater /Aggeryd et al. 1999/. Uranium and thorium have accumulated in the peat in the wetland, and it is likely that the groundwater is a source of these elements.

Carbon, nitrogen and sulphur in peat and fine-grained deposits

The contents of organic carbon (Org. C), sulphur (S), nitrogen (N), calcite ($CaCO_3$) and water (W%) in sediment and peat from lakes, bays and wetlands in the Laxemar-Simpevarp regional model area are shown in Appendix 7 /Nilsson 2004/. The average contents of organic C, N and S in peat, glacial clay and peat are shown in Table 6-25 /Nilsson 2004, Sternbeck et al. 2006/. The average composition of clay gyttja in Lake Frisksjön is presented separately. Carbon, N and S were also analysed by /Engdahl et al. 2006/ and the average contents in glacial clay, gyttja clay and peat are shown in Table 6-20, Table 6-23 and Table 6-24, respectively. These samples were not analysed at the same laboratory as that used by /Nilsson 2004/and the results are therefore presented separately. The organic carbon content can roughly be converted to the total organic content by multiplying by the van Bemmelen factor 1.7 /Jackson 1958/.

The glacial clay has low organic carbon contents (below 1%), and there are at least two factors explaining that: 1) The accumulation rate of minerogenic particles was high during the formation of the glacial clay; 2) The primary production of organic matter was low due to cold climate and/or low concentrations of nutrients.

Clay gyttja has deposited in lakes and bays. There is no large difference in carbon content between clay gyttja sampled in lakes, fens and bays (Table 6-25). However, the highest carbon contents were found in samples from the lakes. Some of these samples have an organic content above 20% and should more correctly be classified as gyttja. The organic sediments from Lake Jämsen and Lake Frisksjön have organic carbon contents of about 20% and gyttja from Lake Plittorpsgöl has organic carbon contents higher than 30%. The sediments in the lakes and fens have been deposited both in lakes and bays and show a larger variability compared with clay gyttja from bays, which has entirely been deposited in bays. The clay gyttja in the present bays has organic carbon contents between 10 and 20%. The clay gyttja used as arable land has been deposited in an environment comparable to the present bays and lakes. It is therefore likely that the clay gyttja in the terrestrial areas has a carbon content similar to that of the clay gyttja in the areas presently covered by water. There is unfortunately only one sample analysed from the areas mapped as clay gyttja in the terrestrial parts of the model area (16%). The two peat samples analysed from the bog Klarebäcksmossen (PSM006562) have carbon contents of about 50% (Table 6-25).

Table 6-25. The average contents of organic carbon, nitrogen (N) and sulphur (S) in clay gyttja, peat and glacial clay /from Nilsson 2004 and Sternbeck et al. 2006/. The nitrogen content of the glacial clay was below the detection limit. The S content was not measured by /Sternbeck et al. 2006/.

	N (C,N)	N (S)	Org. C	Max C	Min C	Tot. S	Max S	Min S	Tot N	Max N	Min N
Peat	5	2	52.4 ± 4.5	56.0	49.3	0.16			1.4 ± 0.6	2.1	0.6
Clay gyttja in fens	13	13	15.3 ± 8.1	34.6	3.6	1.5 ± 1.1	3.9	0.24	1.3 ± 0.6	2.0	0.3
Clay gyttja in lakes	35	31	17.4 ± 8.1	36.9	2.3	1.4 ± 1.2	3.4	0.14	1.6 ± 0.6	2.6	0.2
Clay gyttja in bays	26	14	13.4 ± 1.1	16.7	11.9	2.2 ± 0.5	3.1	1.6	1.7 ± 0.2	2.3	1.4
Clay gyttja (total)	74	58	15.6 ± 6.7	36.9	2.3	1.7 ± 1.1	3.9	0.14	1.6 ± 0.5	2.6	0.2
Clay gyttja in Lake Frisksjön	13	9	20.2 ± 4.0	26.8	15.1	2.3 ± 0.8	3.4	1.1	2.1 ± 0.3	2.6	1.6
Glacial clay	8	8	0.5 ± 0.3	1.0	0.2	0.5 ± 0.5	1.2	0	–	–	–

Higher productivity of organic matter in sheltered bays and lakes compared with the open sea probably caused the relatively high organic carbon content preserved in sediments deposited in these environments /cf Sternbeck et al. 2006/. These sheltered environments are also more favourable for the deposition of fine-grained, organic-rich sediments. The sediments deposited in lakes have a generally higher organic carbon content than sediments deposited in bays /Nilsson 2004/. However, the rates of carbon accumulation are similar in the bays and in Lake Frisksjön /Sternbeck et al. 2006/. The higher carbon content in the lake sediments is probably an effect of lower accumulation rates of minerogenic particles.

In all investigated lakes, C, S and N show an increasing trend from the oldest to the youngest sediments. The total contents of all these elements are relatively low in the glacial clay. The S contents are higher than 1% in most sediments overlying the glacial clay and the highest values, almost 4%, were recorded in the organic rich gyttja sediments (see also Table 6-23). Sulphur in the sediments may in part be associated with organic material, but most sulphur in postglacial organic rich sediments is bound in iron sulphides /cf Sternbeck and Sohlenius 1997/. These sulphides are formed as a consequence of reduction of ferric iron and sulphate during the anaerobic breakdown of organic matter. It is therefore likely that the postglacial gyttja sediments and clay in the Laxemar-Simpevarp area contain significant amounts of iron sulphides. Some of the organic rich lake sediments are, however, low in sulphur indicating low contents of iron sulphides. That may be due to oxidising bottom conditions and/or an effect of the relatively low sulphate content in fresh water. As mentioned above, the high content of S in the clay gyttja reflect the occurrence of iron sulphides. Iron sulphides can easily oxidise if the groundwater table is lowered, due to e.g. artificial drainage or isostatic land upheaval. Oxidation of iron sulphides may cause acid soil condition and increased leaching of trace elements /e.g. Åström and Björklund 1995/. Results from /Lundin et al. 2007/ (see below) suggest that the pH in some of the gyttja soils in the Laxemar-Simpevarp area have been lowered as an effect of sulphide oxidation.

Mineralogy of Quaternary deposits

The mineralogical studies show that the till is dominated by silica-rich primary minerals (Table 6-26 and Table 6-27), similar to these found in the bedrock /Sohlenius et al. 2005a, Lundin et al. 2007/. There is no Swedish database, based on XRD data, showing the average mineralogical composition of till. /Snäll and Ek 2000/ have, however, analysed the mineralogical composition of till from different part of Sweden. The mineralogical composition of the till in the Laxemar-Simpevarp area probably reflects that of the local felsic bedrock /cf Bergman and Sohlenius 2007/. The mineralogical studies also show that till contains clay minerals that have been formed as a result of chemical weathering. All till samples contain a significant amount of vermiculite, indicating clay mineral alteration by chemical weathering. The formation of clay minerals may have taken place in the present till or before the latest ice age.

Most till samples have calcite contents below the detection limit for the method used here Passon apparatus /Almén and Talme 1975/. There are exceptions, however. Two till samples contain significant amounts of calcite (PSM007171 and PSM007173, 2.1 and 4.5% respectively). This is also verified by the results of the XRD analyses (Sample PSM007171). The bedrock in the Laxemar-Simpevarp area does not contain significant amounts of calcite. That mineral must therefore have been transported to the area from somewhere else. The sedimentary limestone at the bottom of the Baltic Sea east of the investigated area is one probable source.

/Lundin et al. 2007/ analysed the mineralogy of postglacial sand (Table 6-27). The results indicate that the mineralogy of the sand resembles that of the local bedrock.

All but one sample from water-laid deposits lack or contain only traces of calcium carbonate. However, one gyttja sample from Långenmossen fen contains 12% $CaCO_3$, which is probably of biogenic origin, i.e. the calcite has precipitated at the site.

/Sohlenius et al. 2006a/ analysed the distribution of clay minerals (XRD) in four clay samples. The results show that illite is the dominant clay mineral, followed by chlorite and kaolinite (Table 6-26). This agrees with other mineralogical studies of water-deposited clay from other

Table 6-26. Mineral composition of the matrix fractions (fractions < 2 mm), /from Sohlenius et al. 2006a/, *A*) in the till samples and the clay fractions (fractions < 2 µm, *B*) in the clay samples. Two X-ray diffraction methods have been used for the analyses: quantitative X-ray diffraction analysis of mixtures of standard minerals (QXRD) and the quantitative Rietveld method. K-fsp. = potassium feldspar, Plag. = plagioclase, Hbl. = hornblende, Kaol. = kaolinite and Verm.=vermiculite.

***A*)**

< 2 mm	Depth (m)	Quartz QXRD %	Rietv %	K-fsp QXRD %	Rietv %	Plag. QXRD %	Rietv %	Hbl. QXRD %	Rietv %	Calcite QXRD %	Rietv %
	Till										
PSM007162	1.0–1.2	25	28	29	25	36	36	4	2		
PSM007171	3.2	26	28	23	23	30	33	3	2	2	1
PSM007180	2.5	24	24	32	27	36	37	0.5	1		
	Clay										
PSM007160*	0.7–0.8	8		5		19		1			
PSM007160	1.25–1.3	8		6		14		3			
PSM007171**	0.5	4		2		13		2			
PSM007171	1.8	9		5		20		2			

***B*)**

< 2 µm		Illite QXRD %	Rietv. %	Chlorite QXRD %	Rietv. %	Kaol. QXRD %	Rietv. %	Verm. QXRD %	Rietv. %
	Till								
PSM007162	1.0–1.2	8	6	3	3	< 0.1		4	
PSM007171	3.2	8	6	8	6	0.1		7	
PSM007180	2.5	7	5	5	5	< 0.1		3	
	Clay								
PSM007160*	0.7–0.8	32		0.7		1		8	
PSM007160	1.25–1.3	45		5		4		3	
PSM007171**	0.5	27		0		1		1	
PSM007171	1.8	33		6		4		0.3	

Table 6-27. Mineral composition of matrix (fraction < 2mm) of two till samples and bulk material of a sand sample /Lundin et al. 2007/. The contents were calculated using the Rietveld method.

Mineral		Till ASM000126	Till PSM001472	Postglacial sand PSM001477
Quartz	%	28.1	27.6	35.8
Potassium feldspar	%	23.5	26.3	25.4
Plagioclase	%	41.5	38.1	34.8
Amphibole	%	1.6	1.6	1.2
Muscovite	%	2.1	3.2	0.7
Chlorite	%	3.1	3.1	2.1
Calcite	%	0.09	0.08	

parts of Sweden, e.g. Uppland /Snäll 2004/. The results imply that most of the clay has been affected only to a small degree by chemical weathering /cf Snäll 2004/. The presence of vermiculite in the clay gyttja from one sample (PSM007160) indicates chemical transformation of the clay minerals.

/Risberg 2002/ analysed the distribution of clay minerals in four clay samples from sediment core (SAS 48) sampled in the bay of Borholmsfjärden south of the island of Äspö. The sediment sequence consists of brownish glacial clay overlain by bluish glacial clay, sand/gravel and gyttja, i.e. in accordance with the general stratigraphy of the area (Table 6-9). The results show that both the bluish and brownish clays were deposited during the brackish phase of the Yoldia Sea. The results from the clay-mineralogical (XRD) analyses show similar distribution of those minerals in the bluish and brownish clays. Reduction of iron in may have caused the bluish colour of the uppermost glacial clay. The distribution of clay mineral in those samples is similar to the results in Table 6-26. Also these results suggest that the clay has only been affected by chemical weathering to a small degree /cf Snäll 2004/.

Chemical composition of soils

Data from the sites studied by /Lundin et al. 2005/ have been compiled (Table 6-29). The soil classes shown in that table are the same as presented on the soil type map (Figure 6-12). In /Lundin et al. 2005/ these properties have been transformed into maps showing the geographical distribution of carbon, pH and N in the different soil horizons. The carbon and nitrogen stocks for the sites, which were studied during the fieldwork, have been calculated. The average carbon stocks for the soil classes shown on the soil type map (Figure 6-12) are presented in Table 6-32. As can be expected the largest carbon stocks are associated with areas classified as Histosol (peat). One exeption is the class HI-w (Open wetland covered by peat), which has an unexpectedly low carbon stock. It is therefore possible that /Lundin et al. 2005/ underestimated the carbon stock in these wetlands.

The average pH and contents of carbon and nitrogen in soils from the Laxemar-Simpevarp regional model area /Lundin et al. 2005/ were compared with the average values for forested areas in Sweden /SML 2006, Table 6-30 and Table 6-31/. The results show that the pH values in the uppermost organic layer (the O horizon) of the soils are similar to the average Swedish values (Table 6-30 and Table 6-31). The average pH in the uppermost mineral layer in the Laxemar-Simpevarp area is higher than the average for Sweden. This is due to the samples from arable land, which generally have a higher pH than equivalent samples from forested land.

The average pH value in the C horizon (55–65 cm) in the Laxemar-Simpevarp area did not differ much from that in the overlying layers. This deviates from the overall pattern for Swedish forest soils, where pH increased more with depth and also showed high values as compared with the results from the Laxemar-Simpevarp area. The reason for this is not known.

The average carbon content in the organic layer in the Laxemar-Simpevarp area is 39%, c 10% in the upper mineral soil layers and only c 1% in the deeper C horizon. Most soils show this pattern, but Histosol with peat, of course, has fairly high carbon content all through the peat deposit. Podsol may exhibit a pattern with a fairly low carbon content in the upper bleached horizon and higher values in the B horizon below, but coming down into the C horizon these soils also have low carbon contents. Nitrogen is an element in organic substances, thereby agreeing fairly well with the organic matter and carbon storage.

/Sohlenius et al. 2006a/ analysed the chemical properties of soils in machine-cut trenches. /Lundin et al. 2007/ analysed the same properties in samples obtained from drillings. All these sites were situated in the clay- and sand-dominated valleys. The analyses included pH, C, N, exchangeable Ca, Mg and K in 1 M NH_4Ac at pH 7 (CEC), titratable acidity, extractable K and P in ammonia lactate (AL) and 2M hydrochloric acid (HCl). Further, *Aqua Regia* extractions were also made with determinations of Fe, Al, Mn, Na, K, Ca, Mg and Zn. Determinations of Fe, Al and Mn in dithionite citrate solution were carried out by /Lundin et al. 2007/.

The samples analysed by /Sohlenius et al. 2006a/ were taken at fixed depth and it is therefore difficult to relate the results to certain QD. One sample may represent two different types of QD's (e.g. sand and clay) with differing chemical properties. The samples analysed by /Lundin et al. 2007/ represent individual types of QD. The results show that the soil chemical conditions are frequently influenced by the high contents of organic material and clay. This results in fairly high pH values both in the upper and deep soil layers. However, some gyttja clay samples analysed by /Lundin et al. 2007/ have rather low pH values (c 4.2). Fine-grained deposits such as clay are often characterised by a higher pH. The low pH in the gyttja samples suggests that sulphide oxidation has lowered the pH in these samples /cf Åström and Björklund 1995/. Carbon and nitrogen show the usual stratification with higher contents in the upper soil layers and decreasing contents with depth. Several of the other analysed elements (base cations, Fe, Al and P) show a partly deviating pattern between the investigated sites. The overall content of elements were however in a similar range and deviated from the large-scale contents in Sweden where the forested till soils provide poorer conditions.

The cation exchange capacity (CEC) provides rough qualitative estimations of the sorption capacity of the different QD. Results of analyses of CEC are shown in Table 6-28 /from Lundin et al. 2007/. As can be expected, the clay samples have a higher CEC than till and sand. The clay gyttja samples have a higher acidity than the other samples. This reflects the rather low pH in these sediments, which is probably due to sulphide oxidation.

Complex-bound elements, as in oxides and amorphous compounds, exert an important influence on the adsorption capacity of elements. One method to find out the amount of complexes is to extract the soil with dithionite citrate solution, which was done on the eight samples. The extraction revealed relatively high contents of extractable Fe in the gyttja and clay deposits as compared with the till and sandy deposits /see Lundin et al. 2007/.

At the sites investigated here, the land classes of arable and pasture exhibit relatively nutrient-rich conditions. For a thorough description of the soil chemical investigation the reader is referred to /Sohlenius et al. 2006a, Lundin et al. 2006,2007/.

Rates of sediment and peat accumulation

The recent and long-term rates of sediment and peat accumulation in the Laxemar-Simpevarp area have been dated by radiometric methods (^{210}Pb and ^{14}C) by /Sternbeck et al. 2006/ (Table 6-33). The results were used to calculate the accumulation rates of carbon, nitrogen and phosphorus (Table 6-34). The average long-term accumulation covers a period of several thousand years and the accumulation rates have probably varied considerably throughout that period.

Table 6-28. Exchangeable cations (NH_4Ac), acidity and cation exchange capacity ($mmol_c$/100g dw) in the eight soils of the Laxemar area.

Sample ID	QD	Mn	Mg	Ca	Na	K	Tot acidity	CEC
ASM000124	Clay gyttja*	0.01	1.90	17.0	0.18	0.23	23.2	42.5
PSM001477	Clay gyttja	0.12	14.9	42.5	0.73	0.31	26.7	85.2
ASM000125	Clay gyttja	0.09	7.59	12.3	1.74	0.64	9.69	32.1
PSM001472	Clay gyttja	0.07	9.27	8.27	3.20	0.96	3.98	25.7
PSM001477	Sand	0.01	0.15	0.59	0.04	0.04	1.19	2.01
PSM001477	Clay	0.05	3.78	7.06	0.29	0.79	1.30	13.3
ASM000126	Till	0.02	0.20	4.14	0.08	0.06	0.00	4.51
PSM001472	Till	0.02	0.13	4.37	0.10	0.05	0.00	4.69

* Classified as peat in the field but the chemical analyses suggest that this sample consists of gyttja sediments.

Table 6-29. Compilation of soil data from the Laxemar-Simpevarp regional model area /Lundin et al. 2005/. In the minerogenic soils, the uppermost organic horizon is denoted by an H. The B horizon is represented by the samples from the M 0–10 cm and M 10–20 cm levels. The C horizon is represented by the sample from the M 55–65 cm level. In Histosol, all layers are denoted by H. In Podsol, the horizon M 0–5 represents the bleached horizon where leaching of e.g. Al and Fe occur. See /Lundin et al. 2005/ for a detailed description of the different soil horizons.

Soil type and abbreviations used in the soil map legend	ID	Horizon	N	Carbon %	Nitrogen %	pH H_2O	pH $CaCl_2$
Podsol/Regosol ***PZ/RG***	ASM001428	H	8	42.6 ± 8.0	1.26 ± 0.30	3.9 ± 0.2	3.2 ± 0.2
Rock outcrops and till, mostly	ASM001428	M 0–5	3	3.7 ± 1.5	0.16 ± 0.06	4.7 ± 0.2	4.1 ± 0.2
coniferous forest	ASM001428	M 0–10	8	4.1 ± 1.6	0.17 ± 0.07	4.5 ± 0.3	3.7 ± 0.3
	ASM001428	M 10–20	4	2.6 ± 1.0	0.12 ± 0.04	5.0 ± 0.2	4.3 ± 0.2
	ASM001428	M 55–65	3	0.5 ± 0.4	0.04 ± 0.02	5.1 ± 0.2	4.5 ± 0.3
	ASM001429	H	8	27.7 ± 7.2	1.02 ± 0.37	4.4 ± 0.3	3.7 ± 0.3
	ASM001429	M 0–5	2	1.2 ± 0.7	0.07 ± 0.03	4.7 ± 0.1	4.0 ± 0.1
	ASM001429	M 0–10	8	2.7 ± 1.9	0.17 ± 0.12	4.8 ± 0.2	4.0 ± 0.2
	ASM001429	M 10–20	8	1.9 ± 1.5	0.12 ± 0.10	5.0 ± 0.1	4.3 ± 0.1
	ASM001429	M 55–65	4	0.5 ± 0.4	0.05 ± 0.02	5.4 ± 0.6	4.7 ± 0.5
Podsol/Regosol ***PZ/RG-e***	ASM001424	H	8	36.9 ± 4.8	1.18 ± 0.12	3.9 ± 0.2	3.2 ± 0.1
Glaciofluvial deposit (esker), mostly	ASM001424	M 0–5	8	2.0 ± 0.5	0.08 ± 0.02	5.0 ± 0.2	4.4 ± 0.4
coniferous forest	ASM001424	M 0–10	8	1.5 ± 0.3	0.06 ± 0.02	4.6 ± 0.1	3.9 ± 0.2
	ASM001424	M 10–20	8	0.9 ± 0.5	0.05 ± 0.02	5.1 ± 0.1	4.6 ± 0.2
	ASM001424	M 55–65	4	0.2 ± 0.2	0.02 ± 0.00	5.1 ± 0.2	4.4 ± 0.4
	ASM001425	H	8	31.3 ± 8.5	1.08 ± 0.30	4.0 ± 0.2	3.2 ± 0.1
	ASM001425	M 0–5	8	2.5 ± 0.6	0.11 ± 0.02	4.8 ± 0.1	4.1 ± 0.1
	ASM001425	M 0–10	8	2.0 ± 0.6	0.09 ± 0.03	4.6 ± 0.1	3.8 ± 0.1
	ASM001425	M 10–20	8	1.5 ± 0.4	0.07 ± 0.02	5.1 ± 0.1	4.4 ± 0.1
	ASM001425	M 55–65	4	0.2 ± 0.1	0.02 ± 0.01	5.3 ± 0.1	4.7 ± 0.1
Umbrisol/Regosol ***UM/RG***	ASM001426	M 0–10	8	11.8 ± 5.9	0.73 ± 0.33	5.3 ± 0.2	4.4 ± 0.2
Deciduous forest at relatively	ASM001426	M 10–20	8	2.9 ± 3.4	0.19 ± 0.18	4.9 ± 0.3	3.9 ± 0.3
nutrient-rich site types	ASM001426	M 55–65	4	0.5 ± 0.5	0.05 ± 0.04	5.2 ± 0.2	4.4 ± 0.3
	ASM001427	M 0–10	8	7.9 ± 3.0	0.51 ± 0.19	5.2 ± 0.2	4.3 ± 0.2
	ASM001427	M 10–20	8	4.2 ± 1.9	0.29 ± 0.11	5.2 ± 0.2	4.2 ± 0.2
	ASM001427	M 55–65	4	1.4 ± 0.7	0.10 ± 0.04	5.2 ± 0.1	4.3 ± 0.1
Umbrisol/Gleysol ***UM/GL***	ASM001430	M 0–10	8	9.7 ± 1.9	0.68 ± 0.15	5.8 ± 0.2	5.0 ± 0.1
Meadow	ASM001430	M 10–20	8	7.5 ± 2.2	0.57 ± 0.16	5.8 ± 0.1	5.0 ± 0.1
	ASM001430	M 55–65	4	0.5 ± 0.3	0.06 ± 0.03	5.5 ± 0.5	4.9 ± 0.5
	ASM001431	M 0–10	8	40.0 ± 4.0	1.69 ± 0.10	5.4 ± 0.1	4.6 ± 0.1
	ASM001431	M 10–20	8	41.5 ± 5.3	1.49 ± 0.09	5.3 ± 0.1	4.6 ± 0.1
	ASM001431	M 55–65	4	3.8 ± 3.0	0.31 ± 0.21	5.0 ± 0.3	4.3 ± 0.3
Umbrisol/Gleysol ***UM/GL-a***	ASM001438	M 0–10	10	10.9 ± 3.6	0.78 ± 0.21	5.7 ± 0.3	5.0 ± 0.2
Arable land	ASM001438	M 10–20	10	11.0 ± 3.2	0.80 ± 0.17	5.7 ± 0.1	5.1 ± 0.1
	ASM001438	M 55–65	5	3.5 ± 6.6	0.41 ± 0.76	5.6 ± 0.4	4.7 ± 0.4
Histosol ***HI-a***	ASM001439	M 0–10	8	21.4 ± 0.8	1.63 ± 0.06	5.1 ± 0.2	4.4 ± 0.1
Arable land	ASM001439	M 10–20	8	21.9 ± 0.6	1.65 ± 0.06	4.9 ± 0.2	4.3 ± 0.2
	ASM001439	M 55–65	4	1.2 ± 1.7	0.15 ± 0.18	–	–

Histosol ***Hl-f***	ASM001440	H 0–30	8	50.4 ± 1.1	2.49 ± 0.16	3.9 ± 0.1	3.1 ± 0.1
Forested (Picea), drained,	ASM001440	H 40–60	4	18.5 ± 1.3	1.29 ± 0.13	4.7 ± 0.2	3.9 ± 0.1
wetlands covered by peat	ASM001441	H 0–30	8	33.1 ± 2.1	1.92 ± 0.10	4.1 ± 0.1	3.6 ± 0.0
	ASM001441	H 40–60	4	46.3 ± 4.0	2.51 ± 0.04	4.3 ± 0.2	3.6 ± 0.1
Histosol ***Hl-f***	ASM001434	H 0–30	8	24.5 ± 2.0	2.05 ± 0.14	5.3 ± 0.5	4.7 ± 0.3
Forested undrained wetlands	ASM001434	H 40–60	4	17.8 ± 1.0	2.15 ± 0.19	4.6 ± 0.6	4.2 ± 0.4
covered by peat	ASM001435	H 0–30	8	40.1 ± 7.6	2.47 ± 0.37	4.3 ± 0.1	3.7 ± 0.2
	ASM001435	H 40–60	4	26.0 ± 8.0	2.04 ± 0.15	4.2 ± 0.3	3.9 ± 0.2
Histosol/Regosol ***Hl/RG***	ASM001436	H 0–30	8	28.9 ± 4.8	1.95 ± 0.14	5.2 ± 0.1	4.8 ± 0.1
Young soils at the shoreline	ASM001436	H 40–60	4	14.1 ± 1.4	1.57 ± 0.20	5.5 ± 0.1	5.2 ± 0.1
	ASM001437	H	3	8.4 ± 5.4	0.83 ± 0.50	6.2 ± 0.2	5.4 ± 0.3
	ASM001437	M 0–10	8	1.4 ± 3.0	0.16 ± 0.28	5.9 ± 0.5	5.3 ± 0.4
	ASM001437	M 10–20	8	1.1 ± 2.4	0.14 ± 0.24	6.0 ± 0.3	5.4 ± 0.3
	ASM001437	M 55–65	4	0.2 ± 0.0	0.04 ± 0.01	5.1 ± 1.1	4.5 ± 0.8
Histosol ***Hl-s***	ASM001432	H 0–30	8	53.0 ± 1.4	1.61 ± 0.22	3.5 ± 0.2	2.9 ± 0.1
Small peatlands surrounded by	ASM001432	H 40–60	5	57.8 ± 1.8	1.94 ± 0.18	4.0 ± 0.2	3.2 ± 0.2
exposed bedrock	ASM001433	H 0–30	8	54.0 ± 0.9	1.46 ± 0.11	3.5 ± 0.1	2.7 ± 0.1
	ASM001433	H 40–60	4	61.2 ± 1.3	0.94 ± 0.08	3.6 ± 0.2	2.7 ± 0.0
Histosol ***Hl-w***	ASM001442	H 0–30	8	49.4 ± 1.3	1.51 ± 0.23	4.7 ± 0.1	4.2 ± 0.1
Open fen areas	ASM001442	H 40–60	4	31.2 ± 8.9	2.02 ± 0.04	4.9 ± 0.3	4.7 ± 0.3
	ASM001442	H 0–30	8	49.6 ± 2.0	1.90 ± 0.25	5.0 ± 0.2	4.3 ± 0.3
	ASM001443	H 40–60	4	27.5 ± 5.3	1.61 ± 0.28	5.0 ± 0.3	4.6 ± 0.3

Table 6-30. Results from the soil survey in the Laxemar-Simpevarp regional model area /from Lundin et al. 2005/. The B horizon is represented by the samples from the M 0–10 cm and M 10–20 cm levels. The C horizon is represented by the sample from the M 55–65 cm level. The O horizon refers to the organic material overlaying the minerogenic soils.

Parameter		Valid N	Average	Min	Max
pH (H_2O)	O horizon	107	4.3	3.3	6.4
	0–10 cm	90	5.2	4.1	6.7
	10–20 cm	86	5.3	4.2	6.5
	55–65 cm	44	5.2	3.6	6.3
Carbon (%)	O horizon	107	39.2	–	55.5
	0–10 cm	90	10.3	–	45.0
	10–20 cm	86	9.2	–	48.4
	55–65 cm	44	1.2	–	15.3
Nitrogen (%)	O horizon	107	1.7	–	3.0
	0–10 cm	90	0.6	–	1.8
	10–20 cm	86	0.5	–	1.7
	55–65 cm	44	0.12	–	1.8

Table 6-31. Reference data from the Survey of forest Soils and Vegetation /SML 2006/, reproduced /in Tröjbom and Söderbäck 2006 from Lundin et al. 2005/. The O horizon refers to the organic material overlaying the minerogenic soils.

Parameter		Valid N	Average	Min	Max
pH (H_2O)	O horizon	6429	4.2	3.0	7.8
	B horizon	1842	4.9	3.8	8.6
	C horizon	484	5.3	3.5	9.2
Carbon (%)	O horizon	5449	33.7	0.0	56.4
	B horizon	1509	2.3	0.0	42.8
	C horizon	1213	0.7	0.0	46.5
Nitrogen (%)	O horizon	5449	1.1	0.0	13.3
	B horizon	1509	0.1	0.0	1.5
	C horizon	1213	0.04	0.0	2.0

Table 6-32. Carbon and nitrogen stocks for the soil type map classes in the Laxemar-Simpevarp regional model area. All values are presented as kg/m². *Depth below the humus layer in cm. C tot and N tot represent the average value for each map class.

Map class	Soil class	Land class	C 0–65*	N 0–65*	C humus	N humus	C tot	N tot
Bedrock	Bedrock		–	–	–	–	0.0	0.0
LP	Leptosol	Rock outcrops and thin soils, mostly coniferous forest	0.34	0.02	2.41	0.08	2.8	0.10
HI-w	Histosol	Open wetland covered by peat	14.7	0.68	–	–	15.6	0.71
			16.6	0.74	–	–		
HI-f	Histosol	Peatlands covered by forest	31.0	2.97	–	–	44.2	2.80
			37.4	2.44	–	–		
			59.7	3.11	–	–		
			48.7	2.78	–	–		
HI-a	Histosol	Arable land on peat					41.5	
HI-s	Histosol	Small wetlands surrounded by exposed bedrock	24.0	0.76	–	–	37.5	0.98
			50.9	1.20	–	–		
RG/HI	Regosol/Histosol	Shore	18.4	1.39			15.1	1.39
			6.54	0.86	5.15	0.52		
UM/GL-a	Umbrisol /Gleysol	Arable land on minerogenic soil	20.5	1.6	–	–	20.5	1.6
UM/GL	Umbrisol/Gleysol	Meadow	27.6	2.13	–	–	39.4	2.26
			51.3	2.39	–	–		
PZ/RG	Podsol/Regosol	Rock outcrops and till, mostly coniferous forest	3.35	0.16	6.17	0.19	8.2	0.38
			3.49	0.27	3.47	0.13		
UM/RG	Umbrisol/Rego-sol	Deciduous forest, mostly till	6.26	0.42	–	–	9.5	0.65
			12.8	0.88	–	–		
PZ/RG-e	Podsol/Regosol	Glaciofluvial deposit (esker), mostly coniferous forest	2.29	0.14	2.74	0.09	5.3	0.24
			2.17	0.13	3.36	0.11		

Table 6-33. Average sediment mass accumulation rates (g m^{-2} yr^{-1}). The ^{210}Pb record covers the 20th century and the ^{14}C dates have been used to calculate the long-term accumulation /from Sternbeck et al. 2006/. (S=sediment, P=peat).

Site	^{210}Pb, average (g m^{-2}yr^{-1})	^{210}Pb, range (g m^{-2}yr^{-1})	Average long term (^{14}C) (g m^{-2}yr^{-1})	Long term cal yrs ago
Lake Frisksjön (S)	410	300–600	400 ± 30	2,600–4,060
Borholmsfjärden (S)	680	470–1,000	680 ± 100	3,300–4,400
Norrefjärd (S)	740	200–1,100		
Granholmsfjärden (S)	380	200–650		
Klarebäcksmossen (P)	450	300–600	56 ± 6	0–8,400

Table 6-34. Average accumulation rates of carbon, phosphorous and nitrogen /from: Sternbeck et al. 2006/. The long term average rates are shown in bold (S=sediment, P=peat).

Depth, cm	Organic carbon accumulation rate (g C m^{-2} yr^{-1})		Phosphorus accumulation rate (g P m^{-2} yr^{-1})		Nitrogen accumulation rate (g N m^{-2} yr^{-1})	
	Average	SD	Average	SD	Average	SD
Lake Frisksjön (S)						
20–22	79	14	0.63	0.13	6.3	0.9
188–431	**74**	**13**	**0.36**	**0.13**	**9.3**	**1.7**
Borholmsfjärden (S)						
20–22	67	8	0.86	0.15	7.8	0.7
280–560	**95**	**18**	**0.49**	**0.07**	**13.6**	**2.1**
Norrefjärd (S)						
2–4	151	22	1.82	0.35	19.3	2.2
10–12	151	22	1.66	0.32	18.1	2.2
20–22	108	16	1.13	0.22	12.5	1.5
32–34	47	7	0.40	0.08	5.6	0.6
Granholmsfjärden (S)						
2–4	78	10	1.25	0.23	9.1	0.9
10–12	45	7	0.67	0.13	4.9	0.6
20–22	26	3	0.38	0.07	3.0	0.3
36–38	28	4	0.30	0.05	3.4	0.3
Klarebäcksmossen (P)						
33–35	137	17	0.18	0.03	2.7	0.2
0–300	**29**	**4**	**0.03**	**0.005**	**0.9**	**0.4**

In the bays, the lowest accumulation rates were found in the bay of Granholmsfjärden. That sampling station is not situated in the deepest part of the basin, which may explain the low rate of accumulation. Lake Frisksjön was isolated from the sea less than 1000 years ago /Brydsten 2006/ and the long-term accumulation rates shown in Table 6-33 and Table 6-34 reflect a period when the present lake was connected to the Baltic Sea. The long-term fluxes of carbon in Lake Frisksjön and the bay of Borholmsfjärden are considerably higher than in the open Baltic Sea /Emeis et al. 2003/. These two basins have to a large extent been surrounded by land for a long period of time and may therefore have had properties similar to lakes. That may explain the high accumulation rates of carbon in these basins. The recent accumulation rates of carbon are also generally higher than values calculated for the open Baltic Sea /Emeis et al. 2000/.

In the bog Klarebäcksmossen the long-term accumulation of peat is similar to accumulation rates calculated for mires in Finland /Turunen et al. 2002/. The recent accumulation of peat in the bog Klarebäcksmossen is much higher than the long-term accumulation. Similar results have been obtained in other studies of peat accumulation in Sweden.

/Kaislahti Tillman and Risberg 2006/ studied the long-term accumulation rate of sediments in two sediment cores sampled outside the Simpevarp archipelago (PSM002118 and PSM002123). They concluded that organic carbon accumulation rate was < 1 g m^{-2} yr^{-1} during the Baltic Ice Lake stage and rose to c 3.5 g m^{-2} yr^{-1} during the Ancylus Lake/and early Littorina Sea stages. In the Littorina Sea, values vary between 10–56 g m^{-2} yr^{-1}. These values are lower than the values obtained by /Sternbeck et al. 2006/ and more similar to values calculated for the open Baltic Sea /Emeis et al. 2000/.

/Lidman 2005/ has used ^{210}Pb dates to calculate the peat growth rate. The accumulation rate is 1.45 ± 0.06 mm/year in the bog Klarebäcksmossen according to these dates. That corresponds to an annual accumulation of material of 51.0 ± 0.8 g m^{-2} yr^{-1}. That implies a lower rate of carbon accumulation compared to the results presented by /Sternbeck et al. 2006/.

As mentioned earlier, the peat is slowly oxidising in areas where the groundwater table has been lowered by ditches. The rate of that oxidation has not been measured in the investigated area. Data presented in /Kasimir-Klemedtsson et al. 1997/ show that the total subsidence in cultivated peat areas can vary between 5 and 30 mm/year. Around 70% of that subsidence can be attributed to oxidation. The lowest values are from areas used for grazing and the higher values are from areas with a more intensive land use, e.g. for cultivation of cereals.

Rates of weathering

Estimation of weathering rates can be used for nutrient budget calculation and to calculate the critical load of acidity. The rate of chemical weathering was not determined during the SKB site investigation.

There are several studies dealing with the weathering rates in Swedish forest soils /e.g. Olsson and Melkerud 1989, Akselsson 2005/. /Akselsson et al. 2004, 2007/ calculated the geographical distribution of weathering rates in till (Ca, Na, K, and Mg) for a large proportion of Sweden. These calculations are to a large part based on SGU's geochemical data from till (see above). /Akselsson et al. 2007/ used SGU's geochemical data from 15 sites in the Laxemar-Simpevarp regional model area to calculate the rate of weathering. These data were provided by Cecilia Akselsson (IVL) and are shown in Table 6-35. The values shown in the table represent the weathering rate in the uppermost 50 cm of the soil profile. It is assumed that the uppermost 50 cm represent the zone from which most plants use nutrients. The results show that the weathering rates in the Laxemar-Simpevarp area are normal in a Swedish context. The rates are, however, slightly lower than the average values from Swedish till soils. /Akselsson et al. 2007/ showed that there is a risk for net losses of K, Ca and Mg from Swedish forest soils. That may negatively affect the future rate of forest growth. The reader is referred to /Akselsson 2005/ for a thorough description of the model used for estimating weathering rates.

Table 6-35. The average rates of weathering of till at 15 sites in the Laxemar-Simpevarp regional model area (calculated for this report by Cecilia Akselsson IVL). The data show the annual rate of weathering in the uppermost 50 cm of the soil profile.

	Average	Median	Max	Min	SD
Ca (mekv m^{-2} yr^{-1})	8.6	8.7	13.3	3.7	2.4
Mg (mekv m^{-2} yr^{-1})	4.4	4.1	7.1	2.1	1.7
K (mekv m^{-2} yr^{-1})	5.1	4.7	6.7	3.5	1.0
Na (mekv m^{-2} yr^{-1})	10.1	10.0	14.5	6.5	2.7

/Olsson and Melkerud 1989/ studied chemical and mineralogical changes during the genesis of a Podsol in southern Sweden. They determined the average rate of weathering since the latest deglaciation (material < 2 mm) and found that the weathering rate has increased recently, possibly due to the influence of acid rain. The long term annual losses in g/m^2 are: Al (1.0), Fe (0.48), Ca (0.27), Mg (0.07), K (0.65), Na (0.53) and P (0.009). These rates may have changed over time due to e.g. climatic variations and different vegetation.

/Ulén and Snäll 1998/ compared the weathering rates in a forest catchment with the rates from an arable field (grain sizes < 2 mm). The rate of base cation weathering was estimated to be 10 times higher in the arable soil compared with the forested area. Soils used as arable land are generally more fine-grained than forest soils. Fine-grained material is more easily affected by weathering and the high weathering rates in the area used as arable land can therefore be explained by a higher soil content of fine material in that area. In the Laxemar-Simpevarp area as well it can be assumed that the weathering rates are much higher in areas with fine-grained sediments (e.g. arable fields) compared to areas with till. The weathering rates shown in Table 6-35 represent values from till, and the equivalent values for clay are likely to be significantly higher.

7 Uncertainties

The uncertainties in the data and models presented in this report are discussed in this section. The uncertainties in the regolith depth and stratigraphy model and the data used for that model are further discussed in /Nyman et al. 2008/.

7.1 The maps of soils and Quaternary deposits

The QD map has been produced by means of several methods (Table 2-1 and Figure 2-2). The reliability of this map therefore varies considerably within the model area.

In Areas 1 and 2 (Figure 2-2), the QD map was produced after extensive field checks. In these areas the quality of the map is high even though minor errors are likely to occur. In Area 2 in particular it is likely that some outcrops and QD of small geographical extent were missed in the field. It is also possible that the area mapped as till is overestimated in the terrestrial area. This is because it is difficult to conclude whether an area with a high frequency of stones and boulders represents a thin till cover (less than 0.5 m) resting directly upon the bedrock or a thick layer of till. The geographical extents of the different mapped QD have different uncertainties depending on the character of the deposits. The boundaries between QD were determined in the field. It is often easy to recognise the transition from clay to till or bedrock. The distinction between different water-laid deposits is much more difficult. Most of the mapped QD are fairly easy to recognise in the field, and only few areas were probably incorrectly mapped after field checks. An additional field check in Area 1 showed, however, that some wetlands with clay gyttja close to the sea have been incorrectly mapped as peat. These wetlands have been above the sea level during a too short period for a distinct peat layer to form.

Sohlenius and Nystrand checked the quality of Areas 3 and 4 in the field. The result of that study was not published. The focus was on the areas where the QD map is mainly based on interpretations of aerial photos, i.e. Areas 3 and 4 in Figure 2-2. It was concluded that forest areas covered with peat are underestimated in these two areas. The forest-covered peat areas are often difficult to recognise in the aerial photos, especially at sites where the groundwater level has been lowered by ditches. One peat area, which is not shown on the QD map, covers several hectares west of Lake Gästern. Most large areas with clay are used as arable land and have been correctly interpreted in the aerial photos. The field check also showed that most areas with bedrock outcrops have been correctly interpreted in the aerial photos. Some small outcrops have, however not been recorded in the aerial photos. It was shown that one area that was mapped as postglacial sand/gravel is in fact of glaciofluvial origin. Thus, it may be difficult to separate glacial sand and gravel deposits from postglacial ones by the use of aerial photos. There are no high-resolution aerial photos from the northwestern part of the regional model area. The QD map shows a lower frequency of bedrock outcrops in that area compared with neighbouring areas. The field check showed that the frequency of bedrock outcrops is strongly underestimated in that particular area. The results from the field check were not used to update the QD map, since too few objects were visited.

Geophysical methods were used to interpret the distribution of QD in the marine areas. In Areas 5, 7, and 9 (Figure 2-2), the distribution of QD was interpreted by means of sonar recordings, which generally have a high quality. However, the sonar recordings have a lower quality in parts of Area 9 and misinterpretations may therefore occur in that area /Kjellin 2007/. In Areas 6 and 8, sonar recordings with a lower quality were used to interpret the distribution of QD. It can sometimes be difficult to distinguish till from bedrock outcrops in these recordings. The areas with till may therefore be underrepresented in these two areas.

Area 10 was not included in the marine geological mapping program. The distribution of QD in that area was interpreted from bathymetric information and from the known distribution of QD in the mapped marine and terrestrial areas. There is almost no bathymetry information outside the archipelago, and in Area 10 the distribution of QD is more or less a matter of guesswork. The geographical distribution of QD in Area 10 shown should therefore not be regarded as an ordinary QD map, but more as a general view of the likely composition of the regolith cover. The interpreted distribution of QD in Area 11 (lakes) is based on a small number of field observations and the reliability of the QD map in that area is consequently low.

In some areas shown as clay or sand on the QD map, the underlying till has probably been exposed on the bottom of the watercourses /cf Carlsson et al. 2005/. Such till exposures are consequently not shown in the regolith depth and stratigraphy model /Nyman et al. 2008/, but may have consequences for the hydrology in the valleys.

The quality of the soil type map has never been cheeked in the field. The map was produced using the properties of soils from 20 sites together with other geographical information. It is likely that there is a larger geographical variability of soil types than was recognised in the survey of the 20 sites. A comparison between the QD map and the soil type map shows that QD with highly different properties are sometimes shown as the same type of soil on the soil type map.

7.2 Total depth and stratigraphy of regolith

Data about the total depth and stratigraphy of the regolith were used for the regolith depth and stratigraphy model /Nyman et al. 2008/. The quality of that model varies with the density of observations reaching the bedrock surface (Figures 2-3 and 2-4). Furthermore, the quality of the regolith depth and stratigraphy model is dependent on the reliability of the methods used to determine the elevation of the bedrock surface. In large parts of the model area, the regolith depths are almost completely derived from the geographical distribution of QD (Figure 6-4) combined with the average thickness of the regolith from areas where data is available. The quality of the QD map consequently has a great impact on the quality of the regolith depth and stratigraphy model.

The surface of the bedrock has been determined by a number of methods. The bedrock outcrops shown on the QD map have been observed in the field, in aerial photos or by geophysical methods. Most of these observations have a high level of confidence and are generally the most reliable data concerning the bedrock surface (Table 7-1). In the marine areas, the distribution of bedrock outcrops shown on the QD map have varying reliability depending on method used. In Areas 5, 7, and 9 the distributions of bedrock outcrops are shown with high reliability. The reliability is lower in Areas 6 and 8 since outcrops may have been partly confused with till in these areas.

At some locations watercourses, have eroded clay deposits and exposed the underlying till. That is not resolved in the regolith depth and stratigraphy model but may have implications for the hydrology in the area close to the boundary between clay and other deposits or in areas where the clay has a small geographical extent.

The most reliable data concerning the depth and stratigraphy of regolith were obtained from drilling and excavations. However, it may be difficult to recognise the difference between till and bedrock with a high frequency of fissures. The frequency of fissures is especially high in the valleys, where data on regolith depths probably has a higher uncertainty than in other areas.

Stratigraphical observations were made in several campaigns. Most of these observations have high reliability. However some of the drilling data, especially till classifications, seem to be less reliable. Younger deposits cover most of the till in the valleys. The properties of the till in these areas have therefore largely been determined on samples obtained from drilling. The properties of these samples may have been altered due to the sampling technique.

Table 7-1. The reliability of the data used to determine the elevation of the bedrock surface. The distribution of the Areas referred to in the table is shown in Figure 2-2.

Type of observation	Area	Reliability	Comment
Bedrock outcrops	Areas 1–5, 7 and 9	High	Reliability is lower in the northwestern part of the model area
	Areas 6 and 8	High–Medium	The bedrock in some areas may be covered with till
	Area 10	Very low	
	Area 11	Medium	
Excavation	Terrestrial	High	
Drilling		High–Medium	It is sometimes difficult to distinguish till from bedrock with a high frequency of fractures
Seismic and sediment echo sounding	Marine	High–Medium	It is sometimes difficult to interpret the thickness of the till
Refraction seismic	Terrestrial/Marine	Medium	These observations permit a more accurate determination of the bedrock surface than resistivity measurements
Resistivity measurements	Terrestrial	Medium	See refraction seismic

The different geophysical methods used to determine the regolith depth have various sources of errors. These errors were discussed with the geophysical experts at SGU. In the marine area (Areas 5 and 6 in Figure 2-2), the depth and stratigraphy of the regolith have been interpreted from the results of seismic and echo sounding. These data have been used to interpret the thickness of the different stratigraphical units, something that not is possible with the other geophysical data. The thickness of the clay deposits can be determined with a relatively high precision using the echo sounding data. However, it may be difficult to interpret the clay thickness in narrow and deep valleys. Furthermore, the clay gyttja often contains gas, which obstructs penetration with the methods used. It has therefore not been possible to determine the stratigraphy and total depth of QD in many areas with clay gyttja. The till thickness interpreted from seismic data has a higher uncertainty than the interpreted clay thickness. One reason for that is that it may be difficult to discriminate thin layers of till from bedrock. It may also be difficult to discriminate till from bedrock with a high frequency of fractures.

In the terrestrial area, refraction seismic and resistivity measurements were used to determine the regolith depths. The depths obtained from the seismic data have medium-high reliability and the error is in most case ± 1 metre. The regolith depths were also interpreted from the inverted resistivity measurements. The electrode separation of 5 m does not provide data to accurately resolve soil cover thinner than around one to two metres. The regolith depths obtained from the resistivity measurements therefore have a lower reliability than corresponding data obtained from refraction seismic.

7.3 Chemical and physical properties of the regolith

The chemical and physical properties of the regolith have been determined by a number of methods. Most analyses were made at laboratories with long experience and data presented in this report can therefore be considered to have high reliability.

SGU and the Swedish University of Agricultural Sciences (SLU) have compared results from the laboratory that carried out the grain size analyses in this report (SWECO Geolab) with results from other laboratories (Unpublished study). The results from that comparison suggest that the grain size analyses carried out at SWECO Geolab can be regarded as reliable.

Some samples analysed for chemical properties in SGU's geochemical mapping programme /Andersson and Nilsson 1992/ were reanalysed by /Lindroos 2004/. The correlation between the results from SGU and the results obtained by /Lindroos 2004/ is high.

It is difficult to conclude whether the analysed properties of the different types of regolith are representative of the whole regional model area. Too few analyses have been performed at some of the deposits. For example, only five samples of peat from the same site were analysed for chemical properties.

Some samples from the valleys, classified as till in the field, are surprisingly well sorted with respect to grain size. All these samples were obtained from drilling and were taken beneath thick layers of glacial and postglacial clay. It is possible that the till in these valleys has a grain size composition, which is different from the till in other parts of the model area. It is also possible that these samples represent another type of deposit than till, e.g. glaciofluvial sediments. However, the properties of these samples may have been altered by the sampling method.

Certain data describing the physical properties of the regolith were taken from the literature. It is not known whether these data are representative for the regolith in the Laxemar-Simpevarp area.

7.4 Summary

The following major uncertainties in the regolith data were recognised:

1) In Areas 3 and 4, large areas with peat are not shown on the QD map.
2) There are almost no field observations of QD in Area 10 and only a few observations are available from Area 11. The QD map from these areas consequently has large uncertainties. That is particularly true of the marine areas outside the archipelago.
3) It is possible that till underlying the clay in some of the large valleys has properties that differ from that of till in other parts of the model area.
4) The soil type map is interpreted from rather few field classifications, and soil types not shown on the soil type map may occur in the model area.
5) Some types of regolith have only been analysed for chemical and physical properties on a few samples.
6) Some of the physical properties were taken from the literature, and it is not known whether these data are representative of the regolith in the model area.

With regard to the regolith depth and stratigraphy model, the following main uncertainties were recognised:

1) There is a lack of data showing the total depth of the regolith in large parts of the regional model area. The regolith depth and stratigraphy model consequently has lower reliability in these areas.
2) The regolith depth has only been determined at a few sites in the large valleys where the thickest layers of regolith occur. It is therefore possible that regolith depths have been underestimated in some of these valleys.
3) The QD map has low reliability in parts of the model area. The regolith depths are modelled in part using that map, and the depth model consequently has low reliability in areas where the QD map has large uncertainties.

8 Resulting description

This section summarises and evaluates the results from the investigations of Quaternary deposits (QD) and soils. The regolith depth and stratigraphy model compiles stratigraphical and surface data obtained from the regional model area. The chemical and physical properties of the different layers used in the regolith depth and stratigraphy model have been calculated.

Figure 6-4, Figure 6-5, Figure 6-6 and Figure 6-11 show the surface distribution of QD in the regional model area. The general stratigraphy for the area is summarised in Table 6-9. The known surface and stratigraphical distribution of QD in the regional model area are in agreement with the conceptual model for the distribution of QD below the highest shoreline in Sweden (Figure 3-2). The average depths of the different QD are shown in Table 6-7 and Table 6-8. Figure 6-21 and Figure 6-22 shows the geographical distribution of regolith depths in the model area.

There is no conclusive evidence of deposits older than the latest glaciation in the Laxemar-Simpevarp area, even though the existence of such deposits cannot be ruled out /cf Lagerbäck et al. 2006/. The bedrock surface in the model area is often rough, indicating a low degree of glacial erosion. However, the absence of regolith predating the last glacial cycle indicates that the Quaternary ice sheets have eroded older loose deposit. The characteristics of the till indicate a short transport distance, and the mineral composition of the till mainly reflects that of the local bedrock. The ice moved from the northwest during the last phase of the latest glaciation. There are indications of older ice movements from the northeast. Material from the Baltic depression may consequently be incorporated in some QD. Calcium carbonate has been recorded in some till samples, which supports that suggestion. The development of the Laxemar area since the latest deglaciation is summarised in Figure 8-1. The salinity variations of the Baltic Sea and the local shoreline displacement are the two most important factors, which have affected that development.

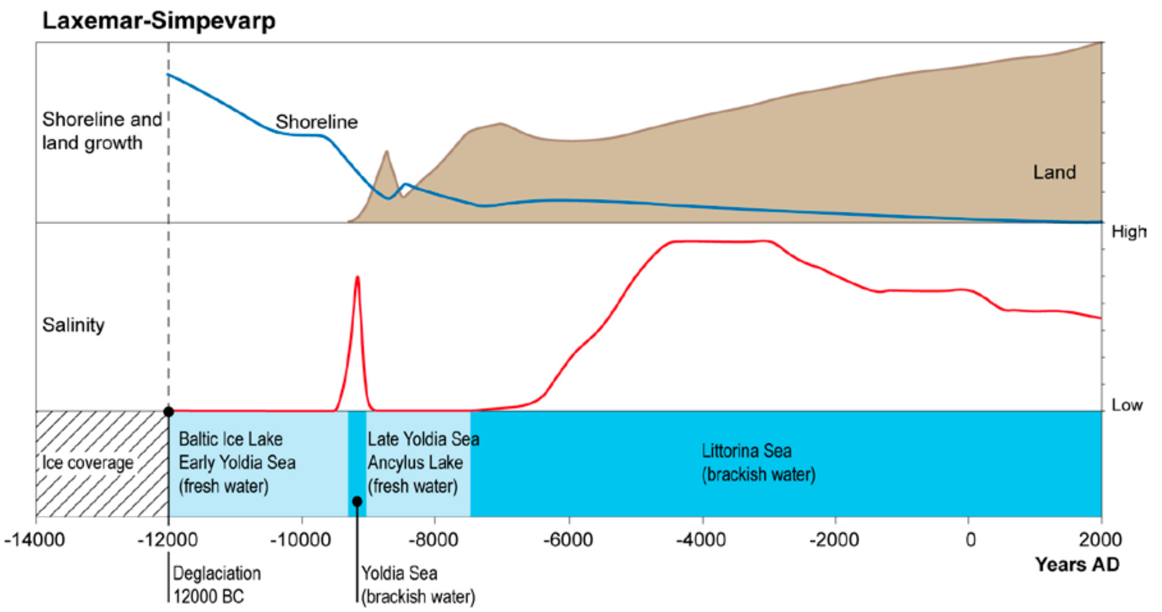


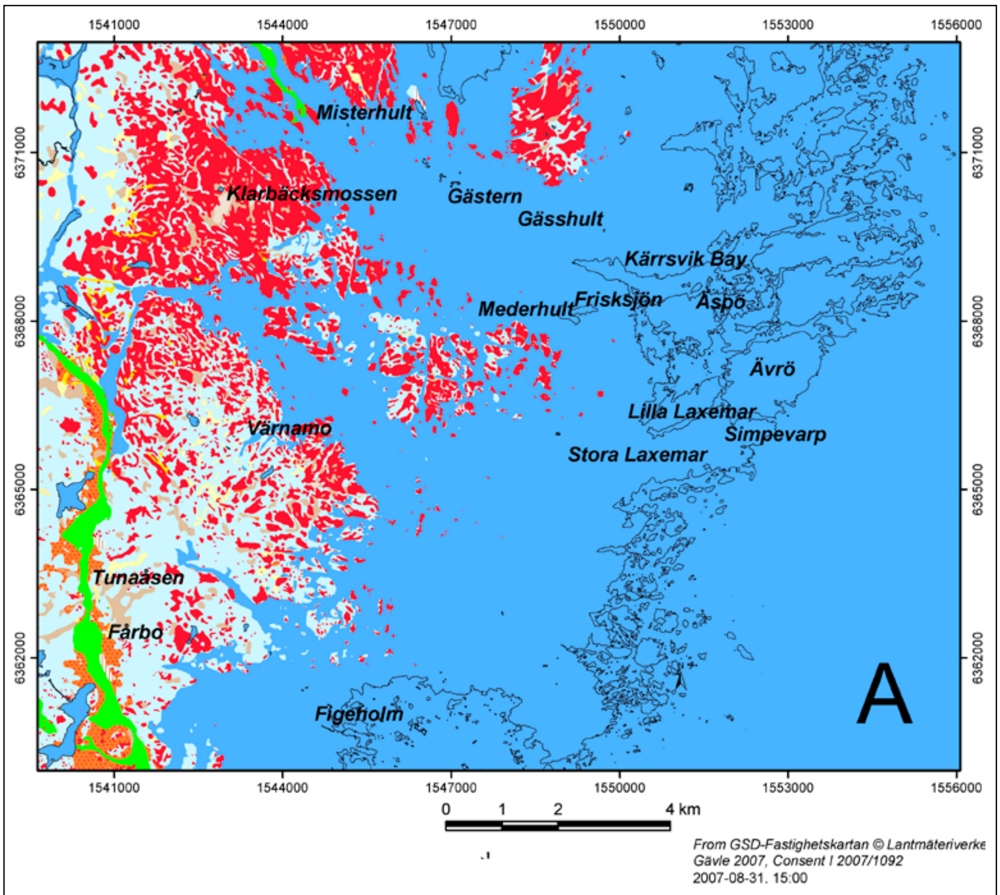
Figure 8-1. *The development of the of the Laxemar Simpevarp area from the latest deglaciation to the present. The red curve shows variations in salinity of the Baltic Sea.*

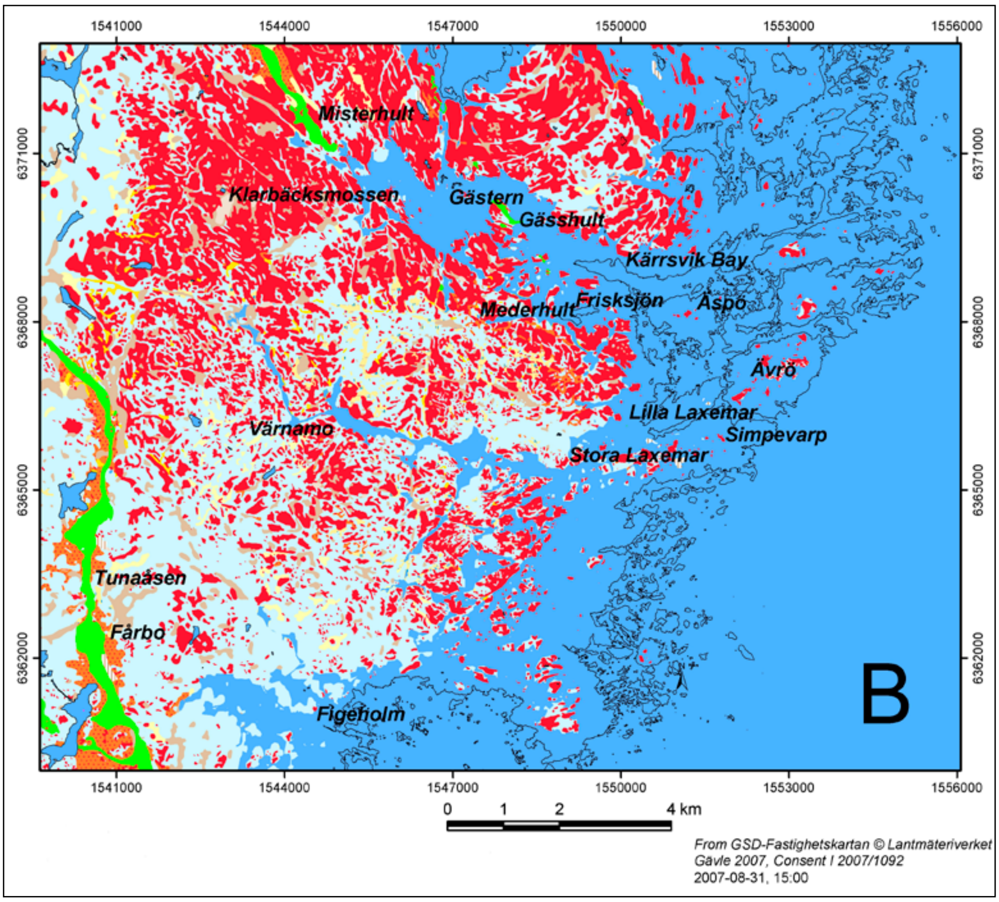
The distribution of fine-grained water-laid QD is mainly related to the local bedrock morphology. These sediments are mostly restricted to the long and narrow valleys which are characteristic of the investigated area. The highest areas have been subjected to erosion from waves and currents. Periods with erosion have occurred in the valleys as well, but it is evident that there have been long periods of deposition of fine-grained material in these areas.

The oldest fine-grained deposit, glacial clay, was deposited during the latest deglaciation when the water was relatively deep. As the water depth decreased, currents and waves started to erode the uppermost clay and deposited a layer sand/gravel on top of the clay. The lowest areas became sheltered bays as the water depth decreased and postglacial clay containing organic material (clay gyttja) started to accumulate. Figure 8-2 A–C shows the former shoreline at three occasions during Holocene. The maps clearly show that the present areas covered with clay gyttja coincide with areas that were once sheltered bays. The processes of erosion and deposition are still active on the sea floor and along the present coast. The floors of many of the valleys are former or present wetlands where layers of peat have accumulated. The areas consisting of wetlands have, however, decreased significantly due to artificial drainage.

The stratigraphical distribution of QD has been obtained from drillings and excavations. The results show that the stratigraphical distribution of QD in the investigated area is rather uniform. Till is the oldest QD in the area and consequently rests directly upon the bedrock surface. The till in the valleys is often overlain by glacial clay, which often is overlain by a layer of sand followed by clay gyttja and peat. The main stratigraphical units are shown in the regolith depth and stratigraphy model. Table 3-1 can be used to explain the different Z-layers used in the model. It should be noted that the layers in the QD depth model might represent more than one type of QD. Figure 3-2 shows the stratigraphical distribution of QD in a valley typical of the model area.

Based on the stratigraphical and geographical distribution of the QD, the area has been divided in three type areas (Figure 8-3), which are discussed below. Note that the type areas were defined based on the distribution of QD. This means that some areas classified as type area I may in fact be situated in valleys, since all till areas are classified as type area I. Areas with artificial fill were not assigned to any type area.





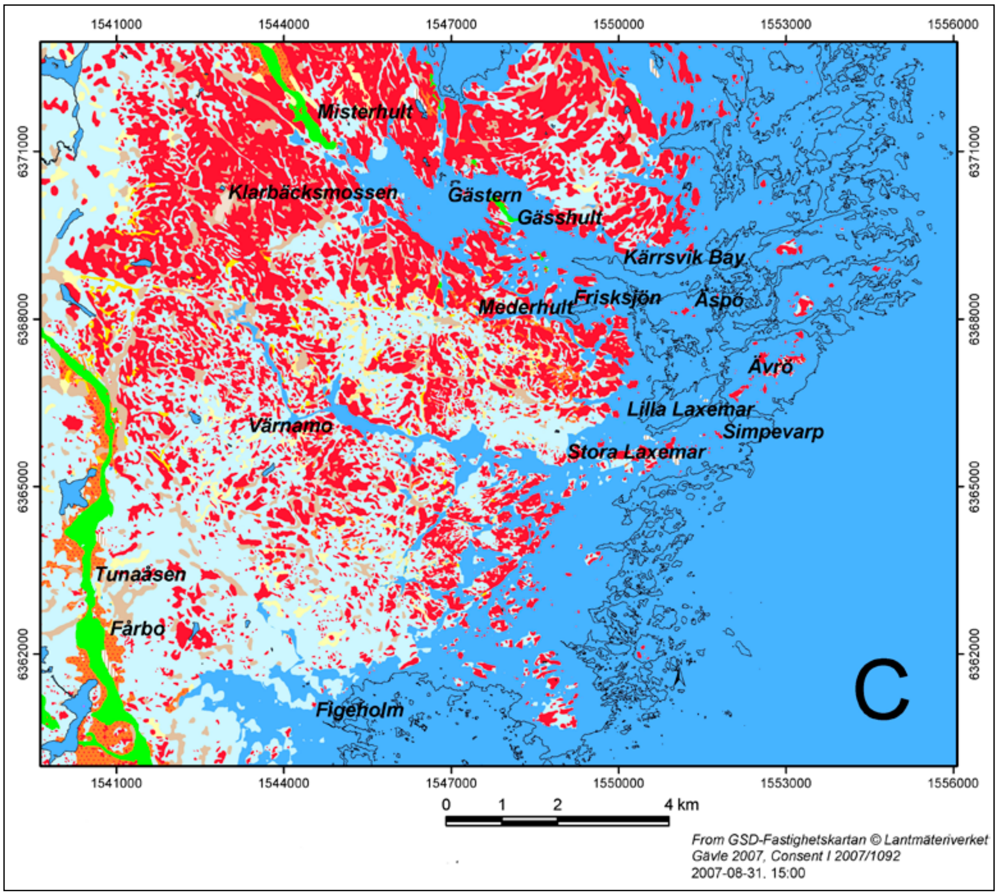


Figure 8-2. *The distribution of land and sea in the Laxemar-Simpevarp area at three different occasions during Holocene, A) 7800 and 8650 BC, B) 3900 BC, C) 1100 BC. Figure A represents two different occasions, one before and one after the Ancylus transgression.*

8.1 Type area I, the topographically high areas

The highest topographic areas are dominated by bedrock outcrops, till and numerous small peatlands (Type areas Ia and Ib in Figure 8-3). The latter are classified as either bogs or fens. In the regolith depth and stratigraphy model the areas with bedrock, till and peat are referred to as domain 1, 2 and 4, respectively (Table 3-2). The regolith in the peat and till areas is generally one or a few metres thick. On land this environment is completely dominated by forest.

8.1.1 Bedrock

The frequency of bedrock outcrops is high in the central and northern parts of the terrestrial areas. The high areas on most of the seafloor outside the archipelago are totally dominated by bedrock outcrops. On land, lichen and mosses cover a large proportion of the naked bedrock. These areas are referred to as bedrock on the soil type map. In the terrestrial areas some of the areas shown as bedrock on the QD map have somewhat richer vegetation and may be partially covered by thin layers of QD. These areas are referred to as Leptosol on the soil type map (Figure 6-12).

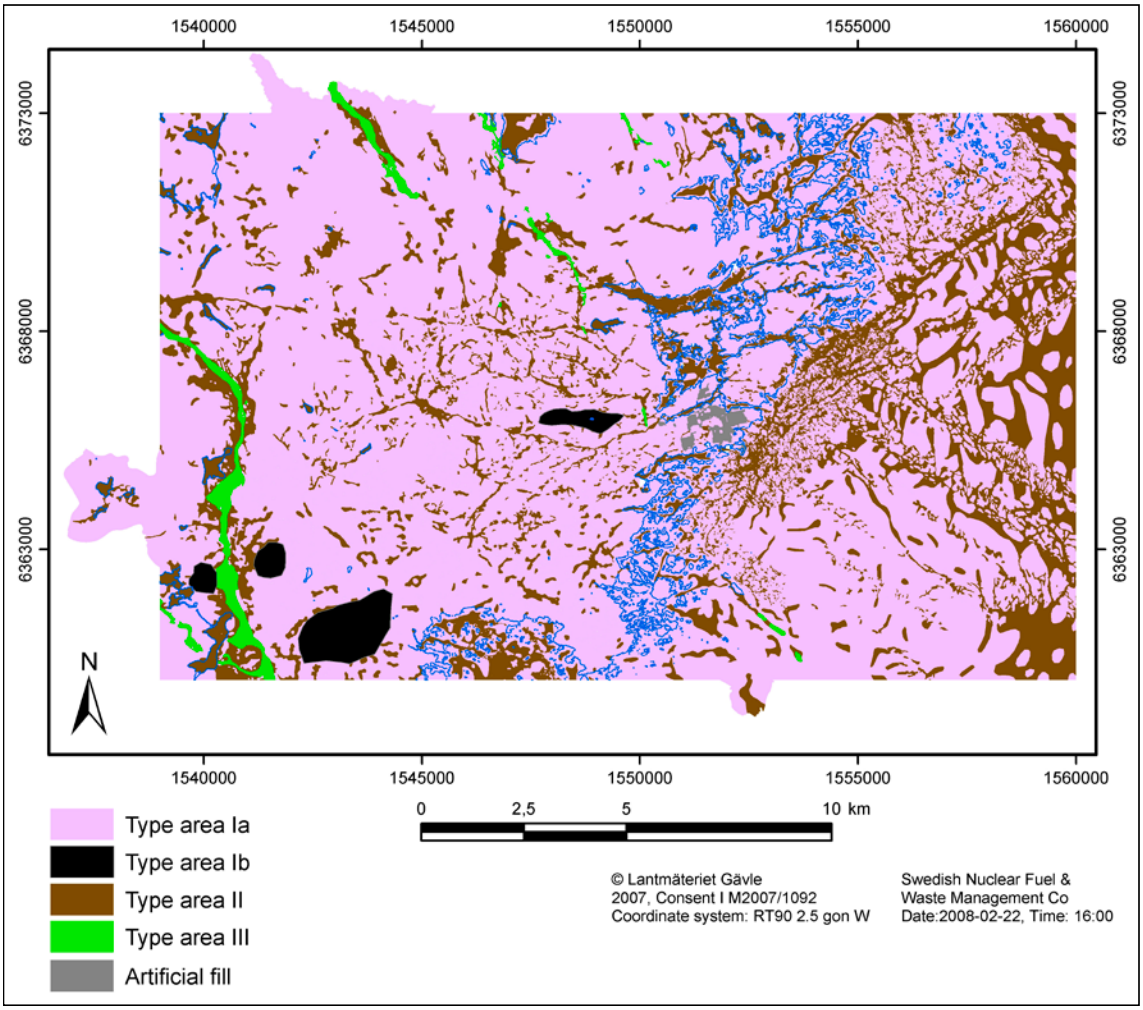


Figure 8-3. *The distribution of the different type areas, defined based on the distribution of QD.*

8.1.2 Till

Till is the most commonly occurring QD in the model area. Most till areas are characterised by a high frequency of bedrock outcrops. Till covers a much larger proportion of the terrestrial areas compared with the marine areas. It is possible that the till coverage in the terrestrial areas is slightly overestimated. Observation on the sea floor shows that a thin boulder layer often covers the bedrock. Such boulder-covered bedrock areas may have been erroneous interpreted as till in the terrestrial areas, where the bedrock is often covered with vegetation. Areas with hummocky moraine and a low frequency of bedrock exposure occur in the southwestern part of the model area, but also in the central part of the Laxemar subarea (Type area Ib in Figure 8-3). The till in that environment is thicker than the till in general. The soils in till areas with coniferous forests are dominated by Podsol and poorly developed soils, Regosol. In till areas with deciduous forest, Umbrisol and Regosol dominate.

8.1.3 Peat

There are numerous small wetlands in the till- and bedrock-dominated areas. Most of these wetlands are covered with peat and are consequently shown as Histosol on the soil type map. Most of the mires are fens where the vegetation gets water from the surrounding land areas. However, some of the mires are bogs where the vegetation receives meteoric water. The mires in the high topographical areas generally have a thinner QD cover compared with the larger present and former wetlands situated in the larger valleys. It is, however, possible that small pockets with thicker QD occur also in these small wetlands. The groundwater table in the relatively small wetlands has usually not been artificially lowered.

8.2 Type area II, the valleys

In the terrestrial area clay gyttja, peat and postglacial sand/gravel dominate the floor of the valleys. Glacial clay and till underlie these deposits. On the sea floor, the valleys close to the coast are dominated by clay gyttja, which is currently being deposited. In the marine areas outside the archipelago, the valleys are dominated by glacial clay covered with a thin layer of postglacial sand. The total thickness of the QD is often several metres in the valleys. Drilling results show a maximum regolith depth of more than 30 metres, while results of geophysical measurements indicate regolith depths of up to 50 metres. In the terrestrial areas, the ground water table in the valleys has often been lowered and the former wetlands are used as arable land.

The character of the valleys varies in the model area, and several types of valleys with different QD can be distinguished. In the regolith depth model the valleys with peat are referred to as domain 5, areas with glacial clay and/or postglacial sand/gravel as domain 6 and areas with clay gyttja as domain 3 (Table 3-2). Results of geophysical measurements and drilling show that the different stratigraphical units are generally thicker in valleys located in the marine area compared with valleys in the terrestrial area.

The valleys reflect lineaments in the bedrock, which are rich in fractures. The bedrock underlying the QD in the valleys is consequently of poor quality and it may sometimes be difficult to define the bedrock-QD interface.

8.2.1 Outside the archipelago

During the deglaciation, glacial clay accumulated on the floor of the valleys in the whole regional model area. The frequency of areas covered with glacial clay is higher on the sea floor outside the archipelago than in other parts of the model area. The high frequency of glacial clay may partly be due to a larger water depth compared to the present land areas. The glacial clay is also much thicker in the marine areas compared with the terrestrial areas.

The valleys on the sea floor outside the archipelago are at present exposed to the erosional forces of waves and streams. There is consequently almost no sedimentation of fine-grained deposits in this area. These valley floors are instead characterised by erosion and transport of sediment. A layer of sand or gravel therefore often covers the glacial clay. The glacial clay in the deepest areas often lacks sand and gravel, which may indicate less intensive erosion in these areas.

8.2.2 Lakes and bays

All of the lakes are former bays that have been isolated from the Baltic Sea due to the isostatic land uplift. Some of the present bays will be lakes in the future if the regressive shoreline displacement continues. The lakes and bays are sheltered from the strong influence of waves and currents. Clay gyttja and gyttja are consequently accumulating on a large proportion of the floors of the lakes and bays. The rate of sediment accumulation is similar in lakes and bays. Several metres of gyttja sediments have been recorded in the deepest parts of the lakes and bays. Peat has started to accumulate along the shores of the lakes, and the size of the lakes will gradually decrease. Several of the lakes have been artificially lowered to obtain land for forest and agriculture. One such example is Lake Gästern, which today is a small lake surrounded by a large wetland, but was much larger before it was lowered in the early 20th century.

8.2.3 Peat areas

The peat areas are both wetlands where peat is currently accumulating and former wetlands where the groundwater table has been artificially lowered. Most of the peat in the valleys is supposed to be underlain by relatively thick layers of clay. The wetlands are characterised by a groundwater table situated close to the ground surface. The high water content causes accumulation of peat, which is formed from the vegetation in the wetlands. Some of the wetlands are former lakes that have been covered with peat. However, many of the present and former wetlands have not experienced a lake stage but were formed directly after the area was raised above sea level. Some of the wetlands situated close to the present sea level lack a peat layer. That is because too short a time has elapsed since the areas were raised above sea level. The areas covered by wetlands have decreased significantly due to lowering of the groundwater table by ditches. That was done for agricultural purposes but also to improve the rate of forest growth. Several of the areas used as arable lands have names ending with “kärret” or “mossen” (fen or bog), which shows that they are former wetlands. The lower groundwater table causes the peat to compact and oxidise and the layer of peat is gradually becoming thinner. The soils in the present and former wetlands are dominated by Histosol. The peat in some of the former wetlands has disappeared due to oxidation and Umbrisol/Gleysol has formed.

8.2.4 Water-laid sediments in the terrestrial areas

Gyttja clay and postglacial sand/gravel dominates the floor in many of the valleys. Since the floor of the valleys at many sites is former wetland, a peat layer covers these sediments in many valleys (see above). The gyttja clay is underlain by postglacial sand/gravel, which in turn is underlain by glacial clay and till. In the terrestrial areas younger deposits often overlie the glacial clay and the area with glacial clay is therefore relatively small on the QD map. The water-laid sediments in the valleys are often used as arable land. Umbrisol/gleysol is the dominant soil type on the fine-grained deposits used as arable land.

8.3 Type area III, the glaciofluvial eskers

There are three small and one large (the Tuna esker) glaciofluvial deposits in the regional model area. These deposits are well sorted with respect to grain size and consist mainly of sand and gravel. The shallow glaciofluvial deposits correspond to domain 7 in the QD depth model and the Tuna esker corresponds to domain 8. During the latest deglaciation the glaciofluvial sediments were deposited in tunnels beneath the ice by meltwater running from the north. The occurrences of subglacially formed eskers indicate bottom-melting conditions during deglaciation. It should be noted that some of the eskers may have been formed during an older deglaciation than the latest one. In the QD depth model, the glaciofluvial sediments rest directly upon the bedrock surface. These deposits are well drained and the vegetation is therefore adapted to dry conditions. Podsol and Regosol are the dominant soil types on the glaciofluvial sediments. On the soil type map, theses soils are distinguished from Podsol/Regosol formed on till (Figure 6-12). It should be noted that the postglacial sand and gravel were also included in this soil type.

8.4 Chemical and physical properties

The most common QD have been analysed with respect to chemical and physical properties. Table 8-1 can be used as a guide to find data describing the properties of the different QD and corresponding layers in the QD depth model. It should be noted that some of the layers in the QD depth model may represent more than one type of QD (see Table 3-1). The uppermost layer, Z1, can be given different properties depending on e.g. QD or soil type. The chemical properties of the different soil types are shown in Table 6-29 and Table 6-30. However, not all soil properties are included in the present report, and the reader is therefore referred to /Sohlenius et al. 2006a, Lundin et al. 2005/ for a complete review of these data.

The properties of the till underlying the sediments in the large valleys have been described in samples obtained from drilling. These samples may have been disturbed during drilling and the properties of the deposits are therefore less well described than the properties of other QD in the model area.

All QD except peat was analysed with respect to grain size. Peat is almost entirely composed of by organic material and was therefore not analysed for grain size composition. Porosity and density have been calculated for some of the QD. Data from the literature have been used for deposits, which lack site-specific data necessary for calculating these values. The till in the area is characterised by low contents of fine material and high contents of sand and gravel. In some of the valleys the till underlying the clay is surprisingly well sorted with respect to grain size. The reason for that is not known.

Table 8-1. This table should be used as a guide to find data describing the physical and chemical properties of the most common QD. C, S, N refer to carbon, nitrogen and sulphur.

Layer in the QD depth model	QD	Physical properties	Chemical properties	C, S, N	Mineralogy
Z1	Top layer of all QD except Z2	Table 6-11, Table 6-13, /Sohlenius et al. 2006a, Lundin et al. 2005/,	/Sohlenius et al. 2006a/, /Lundin et al. 2005/	Table 6-29, Table 6-32	
Z2	Peat	Table 6-11	Table 6-24.	Table 6-25	
Z3	Clay gyttja	Table 6-11, Table 6-12	Table 6-14	Table 6-25	Table 6-26, Table 6-27
Z4	Sand/gravel*	Table 6-11, Table 6-12, Table 6-13	Table 6-22		Table 6-27
Z5	Glacial clay	Table 6-11,Table 6-12	Table 6-20	Table 6-25	Table 6-26, Table 6-27
Z6	Till	Table 6-11, Table 6-12, Table 6-13	Table 6-15, Table 6-16, Table 6-17, Table 6-18,		Table 6-26, Table 6-27

* Including both glacial and postglacial deposits.

The chemical composition of the deposits is close to the Swedish average. The petrographic and mineralogical composition of the till reflects that of the local bedrock even though the till has been transported from the north. However, since the till has been subjected to chemical weathering the chemical composition of the till differs slightly from that of the bedrock. The mineralogy of the clay is different from that of the bedrock since the clay has a high content of clay minerals that were formed after chemical alteration of some of the primary bedrock minerals. Furthermore the chemical composition of clay is also affected by the environmental conditions prevailing during deposition.

It is assumed that the postglacial and glaciofluvial sediments have similar properties. The properties of these deposits are therefore shown jointly. These deposits were deposited in water, and the material originates from till or bedrock.

There are no data describing the physical and chemical properties of the artificial fill. These deposits are a part of the Z4 layer in the QD depth model. Most artificial fill is material, originating from the building of the nuclear power plant. This material probably has a coarse grain size composition and a chemical and mineralogical composition similar to the local bedrock.

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Appendix 1

The stratigraphical distribution of Quaternary deposits observed in machine dug excavations.

Profile	Depth (m)	Quaternary deposit
PSM007160 (Profile 1)	0–0.95	Clay gyttja
	0.95–1.20	Postglacial sand and gravel
	1.2–1.35	Glacial clay
	1.35–3.2	Sandy till
	3.2–	Bedrock
PSM007171 (Profile 3)	0–0.70	Clay gyttja
	0.70–1.30	Postglacial gravel and stones
	1.30–2.9	Glacial clay
	2.9–3.75	Gravelly till
	3.75–	Bedrock
PSM007180 (Profile4)	0–0.90	Postglacial sand
	0.90–1.80	Glacial clay
	1.80–2.40	Glacial silt
	2.40–2.80	Sandy till
PSM007190 (Profile 5)	0.0–1.3	Gyttja
	1.3–3.0	Till*

* It was not possible to properly document this deposit.

Appendix 2

The stratigraphical distribution of QD as interpreted from soil drillings in the Simpevarp and Laxemar subareas.

Id-code	From (m)	To (m)	Quaternary deposit
PSM003509	0.0	0.8	Clay
	0.8	1.2	Till
PSM003510	0.0	2.2	Clay
	2.2	3.0	Till
PSM003511	0.0	1.4	Clay
	1.4	3.6	Till
	3.6	6.4	*Rock*
PSM003512	0.0	1.6	Sandy clay
	0.5	1.6	Clay
	1.6	1.8	Clayey sand
	1.8	2.6	Till
PSM003513	0.0	1.8	Clay
	1.8	2.4	Till
	2.4	3.8	Till?
	3.8	5.4	*Rock*
PSM003514	0.0	2.0	Clay
	2.0	2.4	Till
PSM003524	0.0	0.8	Clay
	0.8	0.9	Clayey sand
	0.9	1.2	Till
PSM003525	0.0	2.4	Clay
	2.4	2.6	Till
PSM003526	0.0	1.0	Clay
	1.0	1.4	Sand
PSM003527	0.0	0.8	Till
PSM003539	0.0	1.4	Clay
	1.4	1.9	Till
PSM003540	0.0	1.2	Clay
	1.2	1.5	Till
PSM003541	0.0	5.0	Clay
	5.0	5.1	Till
PSM003542	0.0	0.6	Clay
	0.6	0.8	Stones
	0.8	2.0	Sandy clay
	2.0	2.4	Till
PSM003543	0.0	1.4	Clay
	1.4	2.2	Till?
	2.2	2.6	Till
PSM003544	0.0	5.6	Clay
	5.6	7.0	Sand
	7.0	7.6	Till

Id-code	From (m)	To (m)	Quaternary deposit
PSM003545	0.0	7.5	Clay
	7.5	11.8	Sand
	11.8	12.6	Till
PSM003546	0.0	7.5	Clay
	7.5	10.8	Sand
	10.8	12.2	Till
PSM003547	0.0	0.8	Peat
	0.8	1.6	Gyttja
	1.6	6.4	Clay
	6.4	6.8	Till
PSM003548	0.0	1.0	Peat
	1.0	2.2	Gyttja
	2.2	2.6	Clay
	2.6	2.7	Till
PSM003551	0.0	0.8	Clay
	0.8	1.0	Till
PSM003552	0.0	2.4	Clay
	2.4	2.6	Till
PSM003553	0.0	1.2	Sandy clay
	1.2	3.8	Clay
	3.8	4.2	Till
PSM003554	0.0	1.2	Sandy clay
	1.2	2.4	Clay
	2.4	2.6	Till
PSM003564	0.0	0.6	Sand
	0.6	0.9	Clay
PSM003565	0.0	0.9	Sand
	0.9	1.0	Clay
	1.0	1.2	Till?
	1.2	2.4	Till
PSM003566	0.0	1.0	Sand/clay
	1.0	1.3	Till
PSM003583	0.0	2.0	Till?
	2.0	3.4	Till
	3.4	5.6	*Rock*
PSM003584	0.0	1.2	Sand
	1.2	1.6	Boulder
	1.6	3.0	Till?
	3.0	3.8	Till
	3.8	5.6	*Rock*
PSM003585	0.0	0.2	Sand
	0.2	2.4	Till?
	2.4	2.8	Boulder
	2.8	4.1	Sandy till
	4.1	7.2	*Rock*

Id-code	From (m)	To (m)	Quaternary deposit
PSM003586	0.0	0.2	Sand
	0.2	2.0	Till?
	2.0	3.0	Sandy till
	3.0	5.6	*Rock*
PSM003591	0.0	0.8	Clay
	0.8	1.8	Sandy till
	1.8	2.4	Till
	2.4	5.5	*Rock*
PSM003592	0.0	1.2	Clay
	1.2	1.8	Till
	1.8	3.2	*Rock*
PSM003630	0.0	1.0	Peat
	1.0	1.5	Gyttja
	1.5	1.5	Boulder/rock
PSM003631	0.0	1.0	Peat
	1.0	1.5	Gyttja
	1.5	1.5	Boulder/rock
PSM003632	0.0	1.6	Sand
	1.6	3.0	Boulder
	3.0	3.8	Sandy till
PSM003633	0.0	0.2	Clay
	0.3	1.6	Clayey silt
	1.6	1.8	Boulder
	1.8	2.2	Sandy till
	2.2	3.8	*Rock*
PSM003634	0.0	0.2	Till
	0.2	1.1	Till?
	1.0	4.0	*Rock*
PSM007148	0.0	5.5	Glaciofluvial sand
	5.5	6.0	Gravelly till
	6.0	8.0	Silty sand till
PSM007149	0.0	5.4	Glaciofluvial sand
	5.4	5.5	Till
PSM007150	0.0	1.0	Peat
	1.0	1.15	Sand
	1.15	3.0	Clay
	3.0	4.0	Silt
	4.0	8.0	Glaciofluvial sand
PSM007151	0.0	1.2	Peat
	1.2	1.8	Clay
	1.8	2.2	Silt
	2.2	3.4	Glaciofluvial sand
	3.4	4.8	Sandy till
PSM007152	0.0	0.5	Peat
	0.5	3.0	Glaciofluvial sand

Id-code	From (m)	To (m)	Quaternary deposit
PSM007153	0.0	0.4	Peat
	0.4	7.0	Glaciofluvial sand
PSM007730	0.0	4.4	Water
	4.4	8.4	Gyttja
	8.4	9.8	Clay
	9.8	11.5	Sandy silty till
PSM007731	0.0	2.9	Water
	2.9	13.0	Gyttja
	13.0	17.8	Clay
	17.8	18.0	Till
PSM007732	0.0	3.5	Peat
	3.5	4.1	Gyttja
PSM001472	0.0	0.7	Peat
	0.7	6.0	Gyttja
	6.0	7.2	Gyttja clay
	7.2	8.5	Postglacial sand
	8.5	11.0	Glacial clay
	11.0	11.9	Sandy till
	11.9	16.2	Gravelly till
PSM001473	0.0	0.8	Peat
	0.8	1.9	Gyttja
	1.9	3.8	Clay gyttja/gyttja clay
	3.8	4.0	Postglacial sand
	4.0	5.8	Glacial clay
	5.8	7.3	Sandy till
PSM001474	0.0	0.9	Peat
	0.9	5.7	Gyttja
	5.7	8.3	Clay gyttja/gyttja clay
	8.3	9.2	Postglacial sand
	9.2	10.4	Glacial clay
	10.4	11.9	Sandy till
PSM001475	0.0	0.5	Peat
	0.5	5.0	Gyttja
	5.0	7.2	Sandy till
PSM001476	0.0	2.9	Peat/gyttja
	2.9	5.6	Postglacial sand
	5.6	7.3	Glacial clay
	7.3	10.6	Till
	10.6	14.5	*Rock*
PSM001477	0.0	0.9	Peat
	0.9	2.6	gyttja
	2.6	3.0	Clay gyttja/gyttja clay
	3.0	5.3	Postglacial sand
	5.3	6.5	Glacial clay
	6.5	10.0	Sandy till

Id-code	From (m)	To (m)	Quaternary deposit
PSM001478	0.0	2.5	Peat/gyttja
	2.5	7.8	Till
	7.8	10.8	*Rock*
PSM001479	0.0	0.7	Peat
	0.7	4.9	Gyttja
	4.9	11.2	Sand
	11.2	14.7	Sandy till
PSM001480	0.0	0.7	Clay gyttja/gyttja clay
	0.7	2.1	Gyttja
	2.1	5.7	Postglacial sand
	5.7	7.8	Glacial clay
	7.8	10.2	Sandy till
PSM001481	0.0	1.5	Peat/gyttja
	1.5	2.7	Postglacial sand
	2.7	5.8	Glacial clay
	5.8	6.5	Till
	6.5	9.5	*Rock*
PSM001483	0.0	1.5	Sand
	1.5	4.4	Till
	4.4	7.5	*Rock*
PSM001484	0.0	7.0	Sandy till
PSM001485	0.0	0.3	Postglacial sand
	0.3	2.5	Glacial clay
	2.5	3.5	Till
PSM001487	0.0	4.8	Sandy till

Appendix 3

The stratigraphical distribution of QD as interpreted during installations of groundwater monitoring wells in the Simpevarp and Laxemar subareas.

IDCODE	From (m)	To (m)	Quaternary deposit
SSM000001	0.0	0.9	Postglacial sand
	0.9	1.3	Clay
	1.3	2.2	Till
	2.2	2.2	*Rock*
SSM000002	0.0	0.6	Postglacial sand
	0.6	0.9	Clay
	0.9	2.1	Till
	2.1	2.1	*Rock*
SSM000004	0.0	2.6	Till
	2.6	2.6	*Rock*
SSM000005	0.0	1.5	Sand
	1.5	1.5	*Rock*
SSM000007	0.0	0.7	Postglacial sand
	0.7	0.9	Clay
	0.9	1.2	Till
SSM000008	0.0	0.5	Sandy clay
	0.5	1.6	Clay
	1.6	4.6	Till
	4.6	7.2	*Rock*
SSM000009	0.0	1.4	Postglacial sand
	1.4	1.5	Clay
	1.5	2.0	Silt
	2.0	3.0	Sandy till
	3.0	4.2	Till
	4.2	5.3	Rock
SSM000010	0.0	1.0	Clay
	1.0	2.0	Till
	2.0	3.6	Rock
SSM000011	0.0	2.0	Till
	2.0	2.8	Sandy till
	2.8	3.6	*Rock*
SSM000012	0.0	0.6	Postglacial sand
	0.6	2.6	Clay
	2.6	3.0	Till
	3.0	5.7	Sandy till
	5.7	6.1	Till
	6.1	9.2	*Rock*
SSM000014	0.0	0.9	Postglacial sand
	0.9	1.0	Clay
	1.0	1.2	Till
	1.2	2.4	Gravelly till
	2.4	5.6	*Rock*

IDCODE	From (m)	To (m)	Quaternary deposit
SSM000015	0.0	0.3	Postglacial sand
	0.3	0.5	Clay
	0.5	0.8	Clayey till
	0.8	1.3	Till
	1.3	1.8	Sandy till
SSM000015	1.8	4.8	Till
	4.8	5.3	*Rock*
SSM000016	0.0	2.6	Till
	2.6	5.8	*Rock*
SSM000018	0.0	1.8	Clay
	1.8	3.0	Clayey till
	3.0	3.2	Till
	3.2	6.2	*Rock*
SSM000020	0.0	0.6	Postglacial sand
	0.6	2.0	Clay
	2.0	2.4	Sandy till
	2.4	5.4	*Rock*
SSM000022	0.0	1.5	Peat
	1.5	1.6	Postglacial sand
	1.6	4.8	Clay
	4.8	5.4	Sandy till
	5.4	8.6	Till
	8.6	11.0	*Rock*
SSM000024	0.0	1.6	Postglacial sand
	1.6	4.2	Sandy till
	4.2	6.2	*Rock*
SSM000026	0.0	0.8	Postglacial sand
	0.8	1.7	Clay
	1.7	4.2	Sandy till
	4.2	7.2	*Rock*
SSM000027	0.0	1.4	Peat
	1.4	1.6	Gyttja
	1.6	1.9	Postglacial sand
	1.9	2.1	Peat/gyttja
	2.1	5.0	Postglacial sand
SSM000028	0.0	1.0	Peat/gyttja
	1.0	2.5	Gyttja
	2.5	2.5	Boulder or rock
SSM000029	0.0	0.5	Peat/gyttja
	0.5	4.3	Gyttja
	4.3	5.5	Fine sand
SSM000030	0.0	0.8	Peat
	0.8	3.0	Gyttja
	3.0	3.8	Sandy till
	3.8	7.0	*Rock*

IDCODE	From (m)	To (m)	Quaternary deposit
SSM000031	0.0	0.5	Peat
	0.5	1.3	Peat/gyttja
	1.3	3.5	Sandy till
SSM000032	0.0	0.4	Peat
	0.4	2.5	Gyttja
	2.5	2.8	Gyttja clay
SSM000033	0.0	0.5	Peat
	0.5	1.0	Sandy clay
	1.0	1.3	Sandy till
SSM000034	0.0	0.5	Peat
	0.5	2.1	Gyttja
	2.1	2.2	Postglacial sand
	2.2	2.8	Sandy clay
	2.8	4.0	Fine sand
SSM000035	0.0	0.7	Unknown
	0.7	2.0	Silt
	2.0	3.5	Sandy silty till
SSM000037	0.0	1.3	Till?
	1.3	3.8	Gravelly till
SSM000039	0.2	2.0	Sand
	2.0	4.2	Sandy till
SSM000040	0.0	1.6	Peat
	1.6	2.3	Sandy till
SSM000041	0.0	1.0	Sand
	1.0	3.0	Sandy silt
	3.0	3.8	Sandy silty till
SSM000042	0.0	3.0	Sand
	3.0	3.5	Sandy till
	3.5	4.5	Rock or boulder
SSM000209	0.0	0.8	Sand
	0.8	1.2	Silt
	1.2	2.8	Sand
	2.8	3.8	Sandy till
SSM000210	0.0	1.6	Till
	1.6	3.8	Sandy till
SSM000211	0.0	1.5	Clayey silt
	1.5	1.8	Sandy till
	1.8	4.0	*Rock*
SSM000212	0.0	1.0	Till?
	1.0	1.8	Sandy till
	1.8	3.8	*Rock*
SSM000213	0.0	0.5	Clay gyttja
	0.5	1.1	Sandy clay
	1.1	1.5	Till
	1.5	3.8	*Rock*

IDCODE	From (m)	To (m)	Quaternary deposit
SSM000222	1.3	4.5	Sandy till
	4.50	7.2	Rock
SSM000223	0.0	0.6	Clay
	0.6	1.1	Sand
	1.1	7.8	Sandy till
	7.8	12.0	*Rock*
SSM000224	0.0	0.9	Artificial fill
	0.9	4.5	sand
	4.5	6.0	clay
	6.0	8.0	silt
	8.0	16.8	Glaciofluvial sand
	16.8	18.6	Sandy till
	18.6	21.2	*Rock*
SSM000225	0.0	0.8	Artificial fill
	0.8	4.8	Sand
	4.8	5.4	Clay
	5.4	8.8	Glaciofluvial sand
	8.8	9.8	Glaciofluvial gravel
SSM000226	0.0	0.6	Peat
	0.6	0.9	Gyttja clay
	0.9	1.2	Postglacial sand
	1.2	2.4	Glacial clay
	2.4	5.0	Till
	5.0	8.0	*Rock*
SSM000227	0.0	0.6	Peat
	0.6	0.9	Gyttja clay
	0.9	1.3	Postglacial sand
	1.3	1.4	Glacial clay
SSM000228	0.0	0.5	Sand
	0.5	2.0	Silt
	2.0	2.8	Sandy silty till
	2.8	5.8	Sandy till
	5.8	8.6	Sandy silty till
	8.6	12.0	*Rock*
SSM000229	0.0	1.0	Silty till
	1.0	2.4	Boulder
	2.4	3.8	Sandy till
	3.8	7.0	*Rock*
SSM000230	0.0	4.6	Glaciofluvial sand
	4.6	7.6	*Rock*
SSM000236	0.0	1.70	Clay
	1.70	2.20	Sandy silty till
	2.20	5.20	*Rock*
SSM000237	0.0	1.9	Clay
	1.9	2.4	Sandy silty till
	2.4	5.3	*Rock*

IDCODE	From (m)	To (m)	Quaternary deposit
SSM000238	0.0	4.4	Water
	4.4	8.4	Gyttja
	8.4	9.8	Clay
	9.8	11.5	Sandy silty clay
	11.5	11.6	*Rock*
SSM000239	0.0	1.4	Water
	1.4	3.2	Gyttja
	3.2	4.2	Sandy silty till
	4.2	4.4	*Rock*
SSM000240	0.0	0.8	Water
	0.8	3.1	Gyttja
	3.1	3.3	Postglacial sand
	3.3	3.7	Glacial clay
	3.7	5.0	Sandy clay
	5.0	5.4	*Rock*
SSM000241	0.0	14.6	Water
	14.6	21.0	Gyttja
	21.0	22.0	Clay
	22.0	22.8	Postglacial sand
	22.8	31.2	Glacial clay
	31.2	32.6	Sandy till
SSM000242	0.0	2.9	Water
	2.9	13.0	Gyttja
	13.0	16.8	Clay
	16.8	17.4	Till
	17.4	17.6	*Rock*
SSM000243	0.0	8.2	Gyttja
	8.2	9.0	Clay gyttja
	9.0	11.0	Clay
	11.0	11.4	Sandy till
	11.4	14.4	*Rock*
SSM000244	0.0	4.6	Gyttja
	4.6	9.6	Sand
	9.6	13.0	Sandy till
	13.0	16.0	*Rock*
SSM000245	0.0	4.0	Peat
	4.0	4.2	Clay gyttja
	4.2	4.4	Sandy till
	4.4	7.4	*Rock*
SSM000246	0.0	3.2	Peat
SSM000248	0.0	0.4	Peat
	0.4	1.2	Sand
	1.2	5.0	*Rock*
SSM000249	0.0	1.1	Peat
	1.1	2.2	Sand
	2.2	6.0	*Rock*

IDCODE	From (m)	To (m)	Quaternary deposit
SSM000250	0.0	0.5	Peat
	0.5	5.2	Sandy till
	5.2	7.1	*Rock*
SSM000251	0.0	0.4	Peat
	0.4	1.1	Sandy till
	1.1	4.2	*Rock*
SSM000252	0.0	0.8	Gyttja
	0.8	1.4	Peat
	1.4	2.0	Gyttja
	1.4	2.8	Postglacial sand
	2.8	4.3	Glacial clay
	4.3	6.6	Sandy till
	6.6	7.3	*Rock*
SSM000253	0.0	0.4	Peat
	0.4	1.0	Clay gyttja
	1.0	1.6	Gyttja
	1.6	1.8	Sand
	1.8	3.6	Sandy till
	3.6	4.0	*Rock*
SSM000254	0.0	0.7	Postglacial sand
	0.7	1.1	Glacial clay
	1.1	2.8	Sandy till
	2.8	5.4	*Rock*
SSM000255	0.0	1.2	Silt
	1.2	2.2	Peat
	2.2	2.3	Postglacial sand
	2.3	3.0	Glacial clay
	3.0	9.0	Sandy clay
SSM000256	0.0	1.8	Clay
	1.8	2.8	Gravelly till
	2.8	4.6	Sandy till
	4.6	5.0	*Rock*
SSM000257	0.0	0.5	Postglacial sand
	0.5	2.8	Glacial clay
	2.8	3.4	Sandy till
	3.4	6.6	*Rock*
SSM000260	0.0	0.8	Peat
	0.8	1.8	Gyttja
	1.8	3.5	Clay gyttja
	3.5	3.9	Gyttja clay
	3.9	4.0	Postglacial sand
	4.0	5.8	Glacial clay
	5.8	7.6	Till
	7.6	8.6	*Rock*

IDCODE	From (m)	To (m)	Quaternary deposit
SSM000261	0.0	0.9	Peat
	0.9	5.7	Gyttja
	5.7	8.3	Clay gyttja
	8.3	9.1	Postglacial sand
	9.1	10.0	Glacial clay
	10.0	11.7	Till
	11.7	14.7	*Rock*
SSM000262	0.0	0.7	Peat
	0.7	3.6	Gyttja
	3.6	4.9	Clay gyttja
	4.9	5.1	Gyttja clay
	5.1	10.0	Postglacial sand
	10.0	11.3	Glacial clay
	11.3	14.7	Till
	14.7	17.8	*Rock*
SSM000263	0.0	1.5	Peat/gyttja
	1.5	4.5	Clay
	4.5	6.3	Till
	6.3	9.3	*Rock*
SSM000264	0.0	1.3	Sand
	1.3	2.8	Till
	2.8	7.0	*Rock*
SSM000265	0.0	0.2	Peat
	0.2	2.5	Clay
	2.5	3.5	Till
	3.5	6.5	*Rock*
SSM000266	0.0	1.2	Clay
	1.2	2.4	Till
	2.4	5.5	*Rock*
SSM000267	0.0	4.8	Till
	4.8	8.2	*Rock*
SSM000268	0.0	0.5	Clay
	0.5	2.7	Till
	2.7	5.7	*Rock*
SSM000269	0.0	0.7	Till
	0.7	3.8	*Rock*
SSM000270	0.0	1.0	Sand
	1.0	1.8	Till
	1.8	3.8	*Rock*
SSM000271	0.0	0.8	Till
	0.8	4.0	*Rock*

Appendix 4

Stratigraphy of sediments and peat sampled in lakes, bays and wetlands /Nilsson 2004/.

Site	Id-code	From (m)	To (m)	Quaternary deposit
Klarbäcksmossen (Bog)	PSM006562	0.00	1.60	Bog peat
		1.60	3.70	Fen peat
		3.70	4.62	Gyttja
		4.62	4.70	Gravel
		4.70	5.24	Postglacial clay
Gäster (Fen)	PSM006563	0.00	0.20	Water
		0.20	4.64	Gyttja/clay gyttja
		4.64	4.66	Postglacial clay
		4.66	4.72	Sand
		4.72	5.38	Postglacial clay
Långenmossen (Fen)	PSM006564	0.00	0.33	Fen peat
		0.33	0.68	Gyttja
		0.68	0.74	Postglacial clay
		0.74	1.90	Gyttja
		1.90	2.32	Calcareous gyttja
		2.32	2.40	Gyttja
		2.40	2.60	Clay gyttja
Hultenäs (Fen)	PSM006565	0.00	0.45	Gyttja
		0.45	0.85	Postglacial clay
Röängen (Fen)	PSM006566	0.00	1.33	Clay gyttja/gyttja clay
		1.33	1.60	Gyttja
		1.60	2.18	Postglacial clay
		2.18	2.19	Sand
		2.19	2.34	Postglacial clay
Hålö (Fen)	PSM006567	0.00	0.20	Water
		0.20	1.13	Gyttja
		1.13	1.18	Gravelly sand
		1.18	1.60	Postglacial clay
Stora Fickssjön (Fen)	PSM006568	0.00	0.15	Water
		0.15	1.00	Gyttja
		1.00	2.05	Clay gyttja/gyttja clay
		2.05	2.12	Sand
		2.12	2.80	Postglacial clay
		2.80	3.00	Glacial sand/silt
Lake Frisksjön	PSM006570	0.00	5.00	Gyttja
Lake Frisksjön	PSM006571	0.00	4.40	Gyttja
Lake Frisksjön	PSM006572	0.00	7.00	Gyttja
Lake Jämsen	PSM006573	0.00	0.05	Water
		0.05	0.59	Clay gyttja
		0.59	1.26	Postglacial clay
		1.26	1.34	Sand
Lake Jämsen	PSM006574	0.00	5.00	Gyttja

Site	Id-code	From (m)	To (m)	Quaternary deposit
Lake Jämsen	PSM006575	0.00	3.85	Gyttja
		3.85	4.25	Postglacial clay
		4.25	5.08	Glacial clay
		5.08	5.10	Sand
Lake Sörås magasinet	PSM006576	0.00	5.40	Gyttja
Lake Sörås magasinet	PSM006577	0.00	3.40	Gyttja
Lake Sörås magasinet	PSM006578	0.00	1.06	Gyttja
		1.06	1.13	Sand
		1.13	1.58	Postglacial clay
		1.58	4.53	Glacial clay
Lake Plittorpsgölen	PSM006579	0.00	1.48	gyttja
		1.48	2.80	Postglacial clay
Lake Plittorpsgölen	PSM006580	0.00	2.45	Gyttja
		2.45	2.58	Postglacial clay
		2.58	3.32	Gyttja clay
		3.32	3.43	Postglacial clay
Lake Plittorpsgölen	PSM006581	0.00	2.55	Gyttja
		2.55	4.00	Gyttja clay
Hamnefjärden (strait)	PSM006582	0.00	0.12	Gravel
Hamnefjärden (strait)	PSM006583	0.00	2.76	Clay gyttja
Hamnefjärden (strait)	PSM006584	0.00	0.05	Water
		0.05	0.71	Gyttja
Bay Äspö Laxemar	PSM006585	0.00	0.15	Water
		0.15	1.35	Gyttja
		1.35	4.80	Clay gyttja
		4.80	4.82	Sand
		4.82	5.08	Postglacial clay
Bay Äspö Laxemar	PSM006586	0.00	1.13	Gyttja
		1.13	3.04	Clay gyttja
Bay Äspö Laxemar	PSM006587	0.00	0.36	Gyttja
		0.36	3.11	Clay gyttja
		3.11	3.17	Sand
Bay Borholmsfjärden	PSM006588	0.00	1.09	Gyttja
		1.09	4.41	Clay gyttja
Bay Borholmsfjärden	PSM006589	0.00	1.30	Gyttja
		1.30	5.88	Clay gyttja
Bay Borholmsfjärden	PSM006590	0.00	0.85	Gyttja

The grain size distribution in 48 till sample. The max and min values are marked with bold and cursive numbers, respectively. The average grain size composition is shown at the bottom of the table. A d60/d10 value below 15 shows that the till is poorly sorted wit respect to grain size.

Id code	Sampling depth (m)	Quaternary deposit	Gravel (%)	Sand (%)	Silt content (%)	Clay content (%)	d60/d10
PSM 007160	2.2	Gravelly till	**75.2**	18.6	**4.4**	1.8	42.2
PSM 007162	1.0	Sandy till	28.9	47.4	19.1	4.6	71.3
PSM 007163	1.0	Gravelly till	32.2	53.7	10.6	3.5	47.7
PSM 007171	3.2	Gravelly till	45.4	43.4	7.8	3.4	57.7
PSM 007173	1.5	Gravelly till	34.2	60.2	2.9	2.7	8.4
PSM 007180	2.5	Gravelly till	35.0	58.2	4.0	2.7	12.3
PSM 005489	1.0	Sandy till	25.3	47.2	24.5	3.1	43.1
PSM 005503	1.0	Sandy till	24.4	57.0	15.4	3.1	62.8
PSM 005505	1.5	Gravelly till	46.1	39.3	12.4	2.2	102.4
PSM 005507	1.0	Gravelly till	41.6	48.7	6.7	3.0	34.1
PSM 005370	0.6	Gravelly till	55.4	32.7	10.5	1.4	93.1
PSM 005372	2.0	Gravelly till	58.8	33.3	6.1	1.7	66.3
PSM 005373	0.7	Sandy till	33.5	49.8	14.1	2.7	59.6
PSM 005374	0.7	Gravelly till	38.9	55.3	3.3	2.5	16.0
PSM 005403	1.5	Gravelly till	51.2	39.4	6.4	3.0	64.0
PSM 005404	1.3	Sandy till	39.5	34.1	20.8	5.7	223.3
PSM 005405	1.0	Clayey sandy till	24.2	42.3	21.4	12.0	–
PSM 005406	1.0	Sandy till	33.4	51.7	10.6	4.3	69.5
PSM 005408	1.2	Gravelly till	45.1	43.9	8.8	2.2	54.5
PSM 005410	0.7	Gravelly till	38.7	46.1	13.3	1.9	73.0
PSM 005412	3.0	Sandy till	37.7	44.0	16.3	2.0	67.2
PSM 002642	2.0	Gravelly till	53.3	39.2	5.5	2.0	30.1
PSM 002643	2.0	Sandy till	30.5	44.6	22.8	2.1	43.0
PSM 002644	0.5	Gravelly till	42.2	40.4	13.8	3.6	165.5
PSM 002683	2.0	Sandy till	25.6	**64.7**	7.4	2.3	8.0
PSM 005385	1.5	Gravelly till	43.4	39.8	13.4	3.4	159.3
PSM 005399	0.8	Gravelly till	37.4	45.7	14.4	2.6	66.9
PSM 005608	3.0	Gravelly till	42.2	47.8	7.6	2.4	36.8
PSM 005634	2.0	Gravelly till	38.4	46.1	13.6	2.0	57.2
PSM006943	0.4	Boulder clay	4.0	25.8	49.6	**20.6**	–
PSM006943	0.6	Clayey sandy till	27.2	38.7	28.0	6.1	153.3
PSM006944	1.0	Clayey sandy till	2.6	21.7	**68.6**	7.1	9.8
PSM006944	1.8	Sandy till	18.2	49.5	28.3	4.0	29.9
PSM006945	1.4	Gravelly till	46.3	39.8	11.1	2.8	88.2
PSM006946	1.0	Gravelly till	46.4	41.3	10.2	2.2	68.4
PSM006947	1.0	Gravelly till	47.8	42.6	6.9	2.6	43.2
PSM006948	1.4	Gravelly till	35.6	51.6	10.8	2.0	39.7
PSM006949	2.1	Sandy till	40.8	29.3	27.6	2.4	159.2
PSM006950	1.1	Sandy till	23.1	64.7	8.9	3.3	10.7
PSM001484	0.2–1.1	Gravelly till	67.5	23.0	7.5	2.0	75.1
PSM001484	1.1–2.1	Gravelly till	61.0	23.7	12.7	2.5	167.2
PSM001484	2.1–3.0	Gravelly till	39.5	40.9	15.2	4.4	138.3
PSM001485	2.5–3.5	Clayey gravelly till	58.2	25.7	8.8	7.3	**693.6**
PSM001487	0.2–1.0	Gravelly till	61.6	28.6	7.8	2.0	73.0
PSM001487	1.0–2.0	Gravelly till	59.3	30.6	8.0	2.1	67.6
PSM001487	2.0–3.5	Gravelly till	53.5	33.9	9.6	3.0	107.9
PSM001487	4.4–4.8	Clayey gravelly till	48.3	30.3	15.9	5.5	433.9
PSM001472	12.0–12.5	Sandy till	28.3	57.2	10.7	3.7	41.2
Average till		**Average till**	*40.1 ± 14.7*	*41.9 ± 11.3*	*14.3 ± 11.6*	*3.7 ± 3.1*	*133 ± 170*

Appendix 6

The grain size composition of water-laid sediments in the Laxemar-Simpevarp regional model area.

Site	Idcode	Sampling depth (m)	Quaternary deposit*	Gravel content (%)	Sand content (%)	Silt content (%)	Clay content (%)
Klarbäcksmossen	PSM006562	4.40–4.60	Gyttja	0	18.8	46.8	34.4
Gästern (F)	PSM006563	0.50–1.00	Gyttja	0	8.8	55.8	35.4
Gästern (F)	PSM006563	4.00–4.64	Gyttja	0	20.5	46.4	33.1
Gästern (F)	PSM006563	1.10–1.50	Gyttja	0	11.0	52.9	36.1
Gästern (F)	PSM006563	4.80–5.20	Postglacial clay**	0	9.5	18.9	71.6
Långenmossen (F)	PSM006564	2.00–2.27	Clay gyttja	0	7.7	70.5	21.8
Långenmossen (F)	PSM006564	2.45–2.60	Clay gyttja	0	9.8	49.7	40.5
Hultenäs (F)	PSM006565	0.00–0.45	Gyttja	0	34.7	33.3	32.0
Hultenäs (F)	PSM006565	0.45–0.87	Clay gyttja	0	34.9	33.0	32.1
Röängen (F)	PSM006566	0.10–0.38	Clay gyttja	0	40.8	39.1	20.1
Röängen (F)	PSM006566	1.33–1.60	Gyttja	0	27.3	44.5	28.2
Hålö (F)	PSM006567	0.25–0.55	Gyttja	0	4.0	46.3	49.7
Hålö (F)	PSM006567	0.60–1.00	Gyttja	0	29.1	44.8	26.1
Hålö (F)	PSM006567	1.28–1.60	Postglacial clay**	0	2.9	23.5	73.6
Stora Fickssjön(L)	PSM006568	0.40–1.00	Gyttja	0	19.5	58.4	22.1
Stora Fickssjön(L)	PSM006568	1.70–2.00	Gyttja clay	0	14.6	26.9	58.5
Stora Fickssjön(L)	PSM006568	2.12–2.80	Postglacial clay**	0	21.8	34.3	43.9
Stora Fickssjön(L)	PSM006568	2.93–3.00	Sand	0	82.4	9.3	8.3
Frisksjön (L)	PSM006570	0.00–0.35	Gyttja	0	5.9	64.9	29.2
Frisksjön (L)	PSM006570	0.35–1.00	Gyttja	0	32.6	47.0	20.4
Frisksjön (L)	PSM006570	4.00–5.00	Gyttja	0	31.8	42.5	25.7
Frisksjön (L)	PSM006571	1.15–2.00	Gyttja	0	16.3	44.6	39.1
Frisksjön (L)	PSM006571	3.00–4.00	Gyttja	0	29.3	38.7	32.0
Frisksjön (L)	PSM006571	0.30–1.00	Gyttja	0	21.0	42.1	36.9
Frisksjön (L)	PSM006572	0.15–1.00	Gyttja	0	21.8	53.4	24.8
Frisksjön (L)	PSM006572	1.00–2.00	Gyttja	0	21.5	48.9	29.6
Frisksjön (L)	PSM006572	5.00–6.00	Gyttja	0	31.0	42.2	26.8
Jämsen (L)	PSM006573	0.13–0.58	Clay gyttja	0	22.1	58.6	19.3
Jämsen (L)	PSM006573	1.00–1.26	Postglacial clay**	0	8.0	61.0	31.0
Jämsen (L)	PSM006574	0.50–1.00	Gyttja	0	17.6	50.7	31.7
Jämsen (L)	PSM006574	4.50–5.00	Gyttja	0	7.8	39.2	53.0
Jämsen (L)	PSM006575	2.60–3.85	Gyttja	0	24.5	49.3	26.2
Jämsen (L)	PSM006575	1.00–2.00	Gyttja	0	17.2	48.1	34.7
Jämsen (L)	PSM006575	4.25–5.00	Glacial clay	0	10.9	40.2	48.9
Sörås mag (L)	PSM006577	0.10–0.50	Gyttja	0	19.8	43.6	36.6
Sörås mag (L)	PSM006577	1.00–1.60	Gyttja	0	22.8	40.7	36.5
Sörås mag (L)	PSM006577	2.60–3.00	Gyttja	0	15.5	43.2	41.3
Sörås mag (L)	PSM006578	0.10–0.60	Gyttja	0	42.3	35.4	22.3
Sörås mag (L)	PSM006578	0.70–1.00	Gyttja	0	55.4	27.5	17.1
Sörås mag (L)	PSM006578	1.15–1.50	Postglacial clay**	0	6.1	30.2	63.7

Site	Idcode	Sampling depth (m)	Quaternary deposit*	Gravel content (%)	Sand content (%)	Silt content (%)	Clay content (%)
Sörås mag (L)	PSM006578	1.60–2.00	Glacial clay	0	20.0	22.2	57.8
Plittorpsgölen (L)	PSM006579	0.00–0.60	Gyttja	0	30.6	52.1	17.3
Plittorpsgölen (L)	PSM006579	1.48–1.90	Gyttja clay	0	10.3	24.7	65.0
Plittorpsgölen (L)	PSM006580	0.40–1.00	Gyttja	0	18.0	38.6	43.4
Plittorpsgölen (L)	PSM006580	0.15–1.00	Gyttja	0	37.0	42.8	20.2
Plittorpsgölen (L)	PSM006580	2.00–2.45	Gyttja	0	36.5	45.9	17.6
Plittorpsgölen (L)	PSM006580	2.58–3.00	Gyttja clay	0	7.1	28.6	64.3
Plittorpsgölen (L)	PSM006581	0.30–1.00	Gyttja	0	31.4	33.9	34.7
Plittorpsgölen (L)	PSM006581	2.00–2.55	Gyttja	0	9.5	40.0	50.5
Plittorpsgölen (L)	PSM006581	3.85–4.00	Gyttja clay	0	13.5	27.4	59.1
Hamnefjärden (SB)	PSM006583	0.06–0.45	Clay gyttja	0	39.5	35.4	25.1
Hamnefjärden (SB)	PSM006583	1.20–2.00	Clay gyttja	0	27.5	42.1	30.4
Hamnefjärden (SB)	PSM006584	0.09–0.71	Gyttja	0	22.5	48.7	28.8
Bay Äspö Laxemar (SB)	PSM006585	0.40–1.00	Gyttja	0	16.3	61.7	22.0
Bay Äspö Laxemar (SB)	PSM006585	3.40–4.00	Clay gyttja	0	15.8	56.8	27.4
Bay Äspö Laxemar (SB)	PSM006585	4.82–5.08	Postglacial clay**	0	1.0	28.4	70.6
Bay Äspö Laxemar (SB)	PSM006586	0.40–1.00	Gyttja	0	29.7	30.9	39.4
Bay Äspö Laxemar (SB)	PSM006586	2.40–2.80	Clay gyttja	0	21.6	54.1	24.3
Bay Äspö Laxemar (SB)	PSM006587	0.37–0.78	Clay gyttja	0	22.7	56.6	20.7
Bay Äspö Laxemar (SB)	PSM006587	1.20–1.80	Clay gyttja	0	17.9	54.9	27.2
Bay Äspö-Hålö (SB)	PSM006588	2.20–2.70	Clay gyttja	0	23.4	51.3	25.3
Bay Äspö-Hålö (SB)	PSM006589	0.18–0.50	Gyttja	0	31.1	48.5	20.4
Bay Äspö-Hålö (SB)	PSM006589	2.20–2.70	Clay gyttja	0	30.5	48.8	20.7
Bay Äspö-Hålö (SB)	PSM006590	0.11–0.65	Gyttja	0	16.2	62.1	21.7
	PSM005309	0.5	Clay gyttja	0	0.7	63.2	36.1
	PSM005309	1	Gyttja	0	2.1	76.5	21.4
	PSM005371	2.2	Postglacial clay**	0	0	23.7	76.3
	PSM002685	1	Clay gyttja	0	15.6	26.7	57.7
	PSM007190	1.1–1.3	Gyttja	0	3.3	71.3	25.4
	SSM000224	12.0–13.0	Sandy gravel	54.9	41.9	2.2	0.9
	SSM000225	2.0–2.8	Sand	3.3	94.2	1.4	1
	PSM007180	0.3	Sand	12.2	86	0.9	0.9
	PSM007180	1	Glacial clay	0.9	13.6	30.3	55.2
	PSM007180	2.3	Clayey silt	0.1	28	65.8	6.1
	PSM007170	1.2	Clay (not spec.)	0	35.1	35.9	29
	PSM007171	0.5	Clay gyttja	1.1	5.1	59.8	34
	PSM007171	1.25	Gravelly sand	47.9	50.1	0.9	1.1
	PSM007171	1.4	Glacial clay	2.6	23.5	31.3	42.7
	PSM007171	1.8	Glacial clay	4.3	14.6	28.7	52.4
	PSM007160	0.7	Gyttja clay	0	0	39.9	60.1

Site	Idcode	Sampling depth (m)	Quaternary deposit*	Gravel content (%)	Sand content (%)	Silt content (%)	Clay content (%)
	PSM007160	1	Gravelly sand	33.9	61.7	1.2	3.3
	PSM007160	1.25–1.3	Glacial clay	0.9	10.1	32.8	56.2
	PSM001472	7.2–8.0	Postglacial sand	2.3	91.9	5.8	0.0
	PSM001472	8.5–10.9	Glacial clay	0.0	0.0	34.3	65.7
	PSM001477	3–5.3	Postglacial sand	0.3	96.7	3.0	0
	PSM001477	5.3–6.5	Glacial clay	0.0	9.9	29.8	60.3
	PSM001479	5.1–9.3	Postglacial sand	1.4	96.5	2.1	0.0
	PSM001480	2.1–5.7	Post-glacial sand	0.3	96.7	3.0	0.0
	PSM001480	5.7–7.8	Glacial clay	0	10.2	30.3	59.5
	PSM001485	0.3–1.0	Glacial clay	0	0.0	32.3	67.7
	PSM001485	1–2.5	Glacial clay	0	0.0	27.1	72.9

(B = Bog. F = Fen. L = Lake. SB = Sea Bay).
* The Quaternary deposits were first classified in the field. Some samples classified as gyttja may therefore have an organic content below 30% and should consequently be classified as clay gyttja.
**All clays with a low organic content are referred to as glacial clays in the text. Some of these clays have been classified as post-glacial clay in the field.

Appendix 7

The contents of organic carbon (Org. C), sulphur (S), nitrogen (N), calcite ($CaCO_3$) and water (W%) in sediment and peat from lakes, bays and wetlands in the Laxemar-Simpevarp regional model area /Nilsson 2004/. All contents except the water content are shown as % of dry sample. The water content is shown as % of water in the wet (fresh) samples.

Site	QD*	Idcode	Sampled depth (m)	Org. C%	S %	N %	$CaCO_3$ %	pH	W %
Klarbäcksmossen (B)	Peat	PSM006562	0.60–0.90	49.3	0.1	0.6	0.0	4.1	92.7
Klarbäcksmossen (B)	Peat	PSM006562	3.20–3.70	56.5	0.23	1.5	0.2	5.4	90.3
Klarbäcksmossen (B)	Gyttja	PSM006562	4.40–4.60	8.5	1.5	0.9	0.2		77.3
Gäster (F)	Gyttja	PSM006563	0.50–1.00	19.0	0.78	1.4	0.2		86.0
Gäster (F)	Gyttja	PSM006563	1.10–1.50	15.6	3.9	1.5	0.6		88.4
Gäster (F)	Postglacial clay**	PSM006563	4.80–5.20	0.4	0.94	–0.1	0.2		45.5
Gäster (F)	Gyttja	PSM006563	4.00–4.64	11.2	1.7	1.5	0.1		78.8
Långenmossen (F)	Gyttja	PSM006564	0.35–0.58	34.6	3.2	2.0	0.3	6.4	89.6
Långenmossen (F)	Calcareous gyttja	PSM006564	2.20–2.27	10.4	1.7	0.8	12.0	8.9	79.6
Långenmossen (F)	Clay gyttja	PSM006564	2.45–2.60	3.6	1.4	0.3	0.3	7.5	70.5
Hultenäs (F)	Gyttja	PSM006565	0.00–0.45	25.4	0.56	1.7	0.2		76.1
Hultenäs (F)	Clay gyttja	PSM006565	0.45–0.87	9.8	0.24	0.6	0.1		66.2
Röängen (F)	Clay gyttja	PSM006566	0.10–0.38	10.8	0.36	0.9	0.1		64.6
Röängen (F)	Gyttja	PSM006566	1.33–1.60	19.4	2.0	1.9	0.1	5.9	79.7
Hålö (F)	Gyttja	PSM006567	0.25–0.55	15.0	0.25	1.6	0.2		85.0
Hålö (F)	Gyttja	PSM006567	0.60–1.00	15.8	2.5	2.0	0.1		87.2
Hålö (F)	Postglacial* clay	PSM006567	1.28–1.68	0.3	1.0	–0.1	0.2		49.1
Stora Fickssjön(L)	Gyttja	PSM006568	0.40–1.00	15.6	0.71	1.1	0.2		83.0
Stora Fickssjön(L)	Gyttja clay	PSM006568	1.70–2.00	2.3	0.25	0.2	0.2		50.0
Stora Fickssjön(L)	Postglacial clay**	PSM006568	2.12–2.80	0.2	–0.1	–0.1	0.2		36.3
Stora Fickssjön(L)	Sand	PSM006568	2.93–3.00				0.1		18.0
Frisksjön (L)	Gyttja	PSM006570	0.00–0.35	26.8	2.5	2.0	0.4		88.2
Frisksjön(L)	Gyttja	PSM006570	0.35–1.00	18.8	3.4	2.1	0.2		88.7
Frisksjön(L)	Gyttja	PSM006570	4.00–5.00	15.3	2.0	2.1	0.3		81.0
Frisksjön(L)	Gyttja	PSM006571	0.30–1.00	26.4	3.0	2.0	0.2		87.7
Frisksjön(L)	Gyttja	PSM006571	1.15–2.00	15.2	2.9	1.9	0.4		83.1
Frisksjön(L)	Gyttja	PSM006571	3.00–4.00	20.5	2.4	2.5	0.1		82.7
Frisksjön(L)	Gyttja	PSM006572	0.15–1.00	17.4	1.2	1.6	0.5		86.1
Frisksjön(L)	Gyttja	PSM006572	1.00–2.00	24.2	1.1	2.1	0.0		90.6
Frisksjön(L)	Gyttja	PSM006572	5.00–6.00	19.5	2.2	2.4	0.2		85.0
Jämsen(L)	Clay gyttja	PSM006573	0.13–0.58	9.2	0.19	0.5	0.3		79.6
Jämsen(L)	Postglacial clay**	PSM006573	1.00–1.26	0.7	0.1	0.0	0.6		50.0
Jämsen(L)	Gyttja	PSM006574	0.50–1.00	20.8	0.3	1.3	0.4		89.3
Jämsen(L)	Gyttja	PSM006574	4.50–5.00	23.7	0.39	1.4	0.6		65.6
Jämsen(L)	Gyttja	PSM006575	1.00–2.00	19.1	0.27	1.4	0.2		86.1
Jämsen(L)	Gyttja	PSM006575	2.60–3.00	12.7	0.34	1.0	0.4		82.8

Site	QD*	Idcode	Sampled depth (m)	Org. C%	S %	N %	$CaCO_3$ %	pH	W %
Jämsen(L)	Glacial clay	PSM006575	4.25–5.00	0.5	–0.1	0.1	0.2		46.4
Sörås mag(L)	Gyttja	PSM006576	0.10–0.80	11.7	3.2	1.3			72.3
Sörås mag(L)	Gyttja	PSM006576	1.00–1.70	13.9	3.0	1.6			71.2
Sörås mag(L)	Gyttja	PSM006577	0.10–0.50	14.3	3.2	1.4	0.2		84.6
Sörås mag(L)	Gyttja	PSM006577	1.20–1.60	12.9	2.5	1.7	0.0		83.4
Sörås mag(L)	Gyttja	PSM006577	2.60–3.00	14.6	2.5	1.8	0.6		77.2
Sörås mag(L)	Gyttja	PSM006578	0.10–0.60	10.9	2.4	1.4	0.5		83.4
Sörås mag(L)	Gyttja	PSM006578	0.70–1.00	12.3	2.0	1.7	0.7		81.4
Sörås mag(L)	Postglacial clay**	PSM006578	1.15–1.50	0.4	0.75	0.1	0.2		49.3
Sörås mag(L)	Glacial clay	PSM006578	1.60–2.00	0.4	–0.1	0.0	0.1		51.4
Plittorpsgölen(L)	Gyttja	PSM006579	0.00–0.60	23.8	0.32	1.6	0.4		87.9
Plittorpsgölen(L)	Gyttja clay	PSM006579	1.48–1.90	3.0	0.14	0.3	0.0		66.9
Plittorpsgölen(L)	Gyttja	PSM006580	0.15–1.00	36.9	0.44	2.0	0.4		92.5
Plittorpsgölen(L)	Gyttja	PSM006580	2.00–2.45	23.5	0.31	1.4	0.4		89.2
Plittorpsgölen(L)	Gyttja clay	PSM006580	2.58–3.00	2.5	0.21	0.3	0.5		62.1
Plittorpsgölen(L)	Gyttja	PSM006581	0.30–1.00	35.6	0.51	2.3	0.0		87.3
Plittorpsgölen(L)	Gyttja	PSM006581	2.00–2.55	23.2	0.36	1.5	0.3		86.7
Plittorpsgölen(L)	Gyttja clay	PSM006581	3.85–4.00	4.8	0.17	0.6	0.3		62.2
Hamnefjärden(SB)	Clay gyttja	PSM006583	0.06–0.45	12.4	2.1	1.7	0.4		82.7
Hamnefjärden(SB)	Clay gyttja	PSM006583	1.20–2.00	13.2	2.0	1.9	1.4		80.6
Hamnefjärden(SB)	Gyttja	PSM006584	0.09–0.71	11.9	1.7	1.6	0.2		81.3
Bay Äspö Laxemar(SB)	Gyttja	PSM006585	0.40–1.00	14.3	2.6	1.8	0.4		88.1
Bay Äspö Laxemar(SB)	Clay gyttja	PSM006585	3.40–4.00	12.5	1.6	1.8	0.4		79.5
Bay Äspö Laxemar(SB)	Postglacial clay**	PSM006585	4.82–5.08	1.0	1.2	0.0	0.6		53.3
Bay Äspö Laxemar(SB)	Gyttja	PSM006586	0.40–1.00	13.4	2.9	1.7	0.4		87.7
Bay Äspö Laxemar(SB)	Clay gyttja	PSM006586	2.40–2.80	12.7	1.6	1.8	1.4		80.0
Bay Äspö Laxemar(SB)	Clay gyttja	PSM006587	0.37–0.78	13.5	2.8	1.6	0.7		85.7
Bay Äspö Laxemar(SB)	Clay gyttja	PSM006587	1.20–1.80	14.2	1.9	1.9	0.6		84.1
Bay Äspö-Hålö(SB)	Gyttja	PSM006588	0.40–1.00	13.6	2.7	1.7	0.5		85.4
Bay Äspö-Hålö(SB)	Clay gyttja	PSM006588	2.20–2.70	13.8	1.9	1.8	0.6		79.8
Bay Äspö-Hålö(SB)	Gyttja	PSM006589	0.18–0.50	12.5	3.1	1.6	0.7		77.1
Bay Äspö-Hålö(SB)	Clay gyttja	PSM006589	2.20–2.70	15.9	2.0	2.2	0.2		77.2
Bay Äspö-Hålö(SB)	Gyttja	PSM006590	0.11–0.65	13.5	2.6	1.8	0.4		85.9

(B = Bog, F = Fen, L = Lake, SB = Sea Bay).
* The Quaternary deposits were first classified in the field. Some samples classified as gyttja may therefore have an organic content below 20% and should consequently be classified as clay gyttja.
**. All clays with a low organic content are referred to as glacial clays in the text. Some of these clays have been classified as post-glacial clay in the field.

Appendix 8

Chemical composition of the most common QD For analyses of As, Cd, Cu, Co, Hg, Ni, Pb, B, Sb, Se and S the samples were digested in HNO_3 and thereafter analysed with ICP-MS. The other elements are presented as the total contents of each element.

Till

The chemical composition of eight till samples.

Id-code	From (m)	To (m)	Org. C mg/kg	Al_2O_3 %	CaO %	Fe_2O3 %	K_2O %	MgO %
PSM007160	2.20	2.20	2600	13.8	1.13	3.22	5.00	1.70
PSM007171	3.20	3.20	–	12.9	2.06	3.67	3.65	1.30
PSM007173	1.50	1.50	–	14.6	2.50	5.00	4.42	2.31
PSM007162	1.00	1.20	–	14.1	1.95	3.30	3.99	1.05
PSM007163	1.30	1.30	–	14.5	2.77	4.83	3.65	1.06
PSM007180	2.50	2.50	–	14.6	1.71	3.87	4.43	1.02
ASM000126			–	14.2	2.49	6.76	3.90	1.04
PSM001472			–	13.6	2.11	7.65	4.14	0.78

Id-code	From (m)	To (m)	MnO %	Na_2O %	P_2O_5 %	SiO_2 %	TiO_2 %	Sum oxides %
PSM007160	2.20	2.20	0.06	3.71	0.16	69.30	0.43	98.50
PSM007171	3.20	3.20	0.06	3.31	0.17	71.60	0.48	99.20
PSM007173	1.50	1.50	0.07	3.27	0.29	65.20	0.71	98.40
PSM007162	1.00	1.20	0.05	3.52	0.17	71.40	0.48	100.00
PSM007163	1.30	1.30	0.07	3.77	0.16	68.30	0.44	99.60
PSM007180	2.50	2.50	0.06	3.74	0.14	69.40	0.36	99.30
ASM000126			0.09	3.74	0.17	68.60	0.53	101.50
PSM001472			0.10	3.60	0.13	68.80	0.36	101.30

Id-code	From (m)	To (m)	LOI %	Ag mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Cd mg/kg
PSM007160	2.20	2.20	1.40	–	1.17	942	1.08	0.02
PSM007171	3.20	3.20	1.70	0.04	0.80	951	2.78	0.04
PSM007173	1.50	1.50	1.70	0.05	0.71	1010	3.12	0.02
PSM007162	1.00	1.20	1.30	–	1.05	906	0.66	0.04
PSM007163	1.30	1.30	0.90	–	0.72	840	0.70	0.03
PSM007180	2.50	2.50	0.80	–	0.93	1100	1.01	0.02
ASM000126			0.20	0.75	1.01	975	2.47	0.03
PSM001472			0.00	0.66	1.35	891	2.61	0.03

Id-code	From (m)	To (m)	Co mg/kg	Cr mg/kg	Cs mg/kg	Cu mg/kg	Ga mg/kg	Hf mg/kg	Hg mg/kg
PSM007160	2.20	2.20	6.5	28.3	0.6	8.4	12.2	4.15	–
PSM007171	3.20	3.20	6.5	32.9	2.7	14.1	11.8	5.42	–
PSM007173	1.50	1.50	11.8	41.4	3.5	18.1	10.9	3.58	–
PSM007162	1.00	1.20	4.9	35.3	1.4	9.0	10.7	5.35	–
PSM007163	1.30	1.30	5.9	58.2	1.5	9.1	14.9	4.39	–
PSM007180	2.50	2.50	6.1	48.8	2.2	10.5	13.5	3.34	–
ASM000126			8.5	75.2	2.3	18.0	16.4	7.71	–
PSM001472			8.1	88.8	2.0	20.0	15.0	6.87	–

Till

Id-code	From (m)	To (m)	Li mg/kg	Mo mg/kg	Nb mg/kg	Ni mg/kg	Pb mg/kg	Rb mg/kg	S mg/kg
PSM007160	2.20	2.20	27.3	0.9	8.9	12.1	6.7	105.0	59
PSM007171	3.20	3.20	25.1	0.8	10.7	9.9	6.8	129.0	297
PSM007173	1.50	1.50	35.2	0.8	7.1	15.7	7.3	123.0	409
PSM007162	1.00	1.20	17.9	0.8	9.9	8.1	8.0	93.8	35
PSM007163	1.30	1.30	16.1	1.1	9.9	12.5	8.3	98.5	50
PSM007180	2.50	2.50	20.5	1.0	7.8	9.3	8.4	114.0	92
ASM000126			14.7	4.8	13.4	43.2	16.2	126.0	222
PSM001472			12.8	6.5	9.9	22.0	15.9	140.0	173

Id-code	From (m)	To (m)	Sb mg/kg	Sc mg/kg	Sn mg/kg	Sr mg/kg	Ta mg/kg	Th mg/kg	Tl mg/kg
PSM007160	2.20	2.20	–	5.2	1.35	354	0.89	17.30	0.06
PSM007171	3.20	3.20	–	5.3	1.07	358	0.99	13.00	0.27
PSM007173	1.50	1.50	–	8.7	0.95	504	0.63	8.53	0.29
PSM007162	1.00	1.20	–	5.7	0.96	497	0.87	10.50	0.15
PSM007163	1.30	1.30	–	5.7	0.87	554	0.83	10.20	0.17
PSM007180	2.50	2.50	–	4.6	0.83	515	0.62	9.27	0.15
ASM000126			0.28	6.9	3.83	536	1.20	10.10	0.52
PSM001472			0.38	5.4	6.98	392	0.85	8.71	0.59

Id-code	From (m)	To (m)	U mg/kg	V mg/kg	W mg/kg	Y mg/kg	Zn mg/kg	Zr mg/kg	Ce mg/kg
PSM007160	2.20	2.20	3.05	33.7	1.05	14.1	67.1	173	67
PSM007171	3.20	3.20	5.03	47.7	3.28	21.0	58.6	214	79
PSM007173	1.50	1.50	2.21	73.9	2.40	18.1	76.4	152	55
PSM007162	1.00	1.20	2.15	44.5	1.26	15.3	45.8	254	42
PSM007163	1.30	1.30	1.94	57.8	1.69	20.0	44.1	198	58
PSM007180	2.50	2.50	2.12	38.9	1.14	14.5	44.3	163	51
ASM000126			4.06	63.6	1.79	21.3	45.1	247	102
PSM001472			3.00	52.4	2.91	16.6	33.8	205	82

Id-code	From (m)	To (m)	La mg/kg	Pr mg/kg	Nd mg/kg	Sm mg/kg	Eu mg/kg	Gd mg/kg	Tb mg/kg
PSM007160	2.20	2.20	33.1	7.6	29.1	4.8	0.6	2.4	0.4
PSM007171	3.20	3.20	39.0	9.6	38.8	4.4	1.0	2.9	0.7
PSM007173	1.50	1.50	26.6	6.0	27.7	4.1	0.7	2.1	0.5
PSM007162	1.00	1.20	20.1	4.7	20.1	2.9	0.5	1.7	0.4
PSM007163	1.30	1.30	27.2	6.5	29.3	4.4	0.8	2.3	0.4
PSM007180	2.50	2.50	25.7	5.4	21.0	2.7	0.4	1.4	0.4
ASM000126			45.7	9.7	34.9	5.8	1.3	4.5	0.6
PSM001472			37.0	7.2	25.5	4.5	0.9	3.4	0.5

Till

Id-code	From (m)	To (m)	Dy mg/kg	Ho mg/kg	Er mg/kg	Tm mg/kg	Yb mg/kg	Lu mg/kg	TS
PSM007160	2.20	2.20	1.66	0.36	1.21	0.13	1.24	0.21	93.0
PSM007171	3.20	3.20	3.09	0.66	1.50	0.30	1.43	0.31	93.5
PSM007173	1.50	1.50	2.09	0.46	1.22	0.20	1.68	0.19	95.2
PSM007162	1.00	1.20	1.91	0.38	1.00	0.21	1.38	0.20	92.1
PSM007163	1.30	1.30	2.68	0.56	1.45	0.21	1.93	0.24	92.0
PSM007180	2.50	2.50	1.64	0.37	1.01	0.14	1.17	0.17	92.9
ASM000126			3.89	0.77	2.29	0.34	2.26	0.37	90.0
PSM001472			3.08	0.63	1.81	0.27	1.79	0.28	93.1

Id-code	From (m)	To (m)	Ash%	Cl mg/kg	I mg/kg	N mg/kg	Org. N mg/kg	PO_4 mg/kg
PSM007160	2.20	2.20		77	–	400	360	44
PSM007171	3.20	3.20		65	–	340	300	42
PSM007173	1.50	1.50		54	–	230	200	50
PSM007162	1.00	1.20		52	–	410	390	60
PSM007163	1.30	1.30		51	–	280	160	52
PSM007180	2.50	2.50		63	–	410	380	45
ASM000126				80	–	–100	–	
PSM001472				67	–	–100	–	

Glacial Clay

Results from chemical analyses of eight samples from glacial clay.

Id-code	From (m)	To (m)	Org. C mg/kg	Al_2O_3 %	CaO %	Fe_2O_3 %	K_2O %	MgO %
PSM007180	1.40	1.40	3400	15.5	1.48	8.19	4.25	2.27
PSM007171	1.40	1.40	1600	15.2	1.33	5.42	4.09	1.77
PSM007171	1.80	1.80	2100	15.6	1.63	7.05	4.13	2.39
PSM007160	1.25	1.30	–1000	16.2	1.54	6.61	4.26	2.35
PSM006563	4.97	5.00	5500	18.3	1.34	8.20	4.59	3.20
PSM006562	4.70	4.75	3800	17.7	1.34	7.24	4.42	2.78
PSM006585	4.97	5.00	5900	17.6	1.15	7.81	4.79	3.21
PSM006562	4.60	4.65	6300	15.5	1.38	5.86	4.38	2.39

Id-code	From (m)	To (m)	MnO %	Na_2O %	P_2O_5 %	SiO_2 %	TiO_2 %	Sum oxides %
PSM007180	1.40	1.40	0.09	1.84	0.19	61.50	0.69	96.00
PSM007171	1.40	1.40	0.05	2.28	0.17	66.10	0.64	97.10
PSM007171	1.80	1.80	0.09	2.06	0.18	63.80	0.69	97.60
PSM007160	1.25	1.30	0.06	1.75	0.19	62.90	0.69	96.60
PSM006563	4.97	5.00	0.07	1.52	0.23	55.20	0.76	93.40
PSM006562	4.70	4.75	0.07	1.67	0.18	58.30	0.79	94.50
PSM006585	4.97	5.00	0.08	1.92	0.22	52.60	0.73	90.10
PSM006562	4.60	4.65	0.06	1.78	0.17	57.10	0.69	89.30

Id-code	From (m)	To (m)	LOI %	Ag mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Cd mg/kg
PSM007180	1.40	1.40	3.80	0.09	5.22	693	2.41	0.08
PSM007171	1.40	1.40	3.40	0.07	3.58	686	1.89	0.15
PSM007171	1.80	1.80	3.40	0.11	3.22	705	2.57	0.07
PSM007160	1.25	1.30	4.60	0.08	3.13	686	2.37	0.17
PSM006563	4.97	5.00		0.14	3.29	509	3.94	0.07
PSM006562	4.70	4.75		0.44	1.71	703	3.93	0.23
PSM006585	4.97	5.00	6.40	0.30	5.29	651	3.43	0.11
PSM006562	4.60	4.65		–0.02	1.46	746	3.18	0.12

Id-code	From (m)	To (m)	Co mg/kg	Cr mg/kg	Cs mg/kg	Cu mg/kg	Ga mg/kg	Hf mg/kg	Hg mg/kg
PSM007180	1.40	1.40	17.4	86.2	6.8	27.4	17.4	6.43	–0.04
PSM007171	1.40	1.40	12.7	72.9	5.1	21.2	13.7	4.96	–0.04
PSM007171	1.80	1.80	15.7	89.9	6.7	29.4	14.0	4.34	–0.04
PSM007160	1.25	1.30	13.7	85.9	6.1	25.9	17.3	6.30	–0.04
PSM006563	4.97	5.00	22.0	98.2	10.0	30.9	73.1	3.72	–0.02
PSM006562	4.70	4.75	19.1	90.1	9.9	27.0	42.3	4.67	–0.02
PSM006585	4.97	5.00	19.8	89.1	10.4	27.3	9.5	3.41	–0.04
PSM006562	4.60	4.65	17.6	85.9	7.7	24.8	24.0	4.25	–0.02

Glacial Clay

Id-code	From (m)	To (m)	Li mg/kg	Mo mg/kg	Nb mg/kg	Ni mg/kg	Pb mg/kg	Rb mg/kg	S mg/kg
PSM007180	1.40	1.40	43.1	0.6	15.6	28.5	20.4	142.0	125
PSM007171	1.40	1.40	32.3	0.4	13.5	21.8	16.0	133.0	2060
PSM007171	1.80	1.80	40.3	0.7	14.8	27.6	19.1	123.0	199
PSM007160	1.25	1.30	43.1	0.4	14.9	32.8	22.0	155.0	74
PSM006563	4.97	5.00	73.0	–2.0	18.0	38.9	32.5	221.0	10400
PSM006562	4.70	4.75	58.7	–2.0	14.9	32.3	29.9	210.0	129
PSM006585	4.97	5.00	58.8	–6.0	14.2	36.0	31.1	211.0	13200
PSM006562	4.60	4.65	46.7	–2.0	14.5	27.8	27.5	161.0	160

Id-code	From (m)	To (m)	Sb mg/kg	Sc mg/kg	Sn mg/kg	Sr mg/kg	Ta mg/kg	Th mg/kg	Tl mg/kg
PSM007180	1.40	1.40	–0.04	13.1	1.21	173	1.47	19.40	0.67
PSM007171	1.40	1.40	–0.04	11.4	0.82	221	1.13	17.30	0.54
PSM007171	1.80	1.80	–0.04	12.9	1.24	200	3.62	19.10	0.71
PSM007160	1.25	1.30	–0.04	13.9	0.68	179	1.36	18.40	0.64
PSM006563	4.97	5.00	0.40	17.6	2.92	167	1.07	17.50	1.25
PSM006562	4.70	4.75	0.51	16.6	3.70	136	1.36	19.10	1.29
PSM006585	4.97	5.00	0.41	17.1	–	134	1.34	18.00	1.25
PSM006562	4.60	4.65	0.40	14.3	2.93	168	1.18	15.30	1.28

Id-code	From (m)	To (m)	U mg/kg	V mg/kg	W mg/kg	Y mg/kg	Zn mg/kg	Zr mg/kg	Ce mg/kg
PSM007180	1.40	1.40	3.09	94.7	1.76	37.7	96.9	276	85
PSM007171	1.40	1.40	3.23	82.3	2.61	29.3	83.9	255	72
PSM007171	1.80	1.80	3.20	91.6	1.52	35.4	94.0	237	73
PSM007160	1.25	1.30	3.65	100.0	2.65	37.8	103.0	248	94
PSM006563	4.97	5.00	5.49	128.0	1.88	37.8	120.0	179	101
PSM006562	4.70	4.75	7.01	120.0	3.16	41.5	117.0	211	113
PSM006585	4.97	5.00	5.44	120.0	–60.00	39.2	121.0	176	112
PSM006562	4.60	4.65	5.74	103.0	2.37	17.3	92.3	188	97

Id-code	From (m)	To (m)	La mg/kg	Pr mg/kg	Nd mg/kg	Sm mg/kg	Eu mg/kg	Gd mg/kg	Tb mg/kg
PSM007180	1.40	1.40	37.7	10.3	40.9	6.5	0.8	4.9	0.9
PSM007171	1.40	1.40	32.2	8.0	29.2	5.0	0.7	3.9	0.7
PSM007171	1.80	1.80	31.7	7.7	31.9	4.8	0.7	3.6	0.8
PSM007160	1.25	1.30	42.9	10.7	47.6	7.6	1.3	5.4	1.1
PSM006563	4.97	5.00	44.4	13.3	44.9	7.7	1.3	6.7	0.6
PSM006562	4.70	4.75	55.9	13.6	50.5	9.4	1.5	6.7	0.8
PSM006585	4.97	5.00	53.4	12.9	52.6	7.5	1.4	7.0	0.9
PSM006562	4.60	4.65	51.5	11.3	41.9	7.0	1.0	5.8	0.6

Glacial Clay

Id-code	From (m)	To (m)	Dy mg/kg	Ho mg/kg	Er mg/kg	Tm mg/kg	Yb mg/kg	Lu mg/kg	TS
PSM007180	1.40	1.40	4.86	0.84	2.89	0.44	3.32	0.48	80.6
PSM007171	1.40	1.40	3.62	0.77	1.83	0.26	2.65	0.30	73.6
PSM007171	1.80	1.80	4.06	0.83	2.42	0.31	2.94	0.27	70.3
PSM007160	1.25	1.30	5.70	1.11	3.17	0.60	3.36	0.59	72.2
PSM006563	4.97	5.00	5.84	1.28	3.99	0.58	2.98	0.44	44.0
PSM006562	4.70	4.75	7.27	1.43	4.21	0.67	3.90	0.51	98.0
PSM006585	4.97	5.00	6.06	1.16	3.16	0.55	3.71	0.48	43.8
PSM006562	4.60	4.65	6.29	1.20	3.52	0.48	3.18	0.43	98.3

Id-code	From (m)	To (m)	Ash%	Cl mg/kg	I mg/kg	N mg/kg	Org. N mg/kg	PO_4 mg/kg
PSM007180	1.40	1.40		–25	–0.50	300	230	40
PSM007171	1.40	1.40		32	–0.50	310	240	81
PSM007171	1.80	1.80		–25	–0.50	580	480	64
PSM007160	1.25	1.30		32	–0.50	780	680	38
PSM006563	4.97	5.00	97.0	1980	–1.00	763	413	440
PSM006562	4.70	4.75	96.7	–50	–1.00	1030	855	31
PSM006585	4.97	5.00		6440	3.96	11100	9080	512
PSM006562	4.60	4.65	96.6	–50	–1.00	233	–5	24

Sand

Results from chemical analyses of the eight samples from sand.

Id-code	From (m)	To (m)	Org. C mg/kg	Al_2O_3 %	CaO %	Fe_2O3 %	K_2O %	MgO %
SSM000224	12.00	13.00	–1000	15.4	2.37	4.43	4.17	1.62
SSM000225	2.00	2.80	–1000	12.7	1.62	3.48	4.08	0.54
PSM006585	4.80	4.82	69000	7.3	1.31	2.45	2.09	1.27
PSM006563	4.66	4.70	6800	12.0	1.61	1.72	3.72	0.55
PSM007160	1.00	1.10	5900	15.2	2.18	3.37	3.93	0.79
PSM007171	1.25	1.25	2200	14.7	2.19	5.19	3.74	1.77
PSM007180	0.30	0.30	–1000	14.3	1.49	2.82	4.38	0.49
PSM001477			820	12.4	1.38	5.06	3.89	0.40

Id-code	From (m)	To (m)	MnO %	Na_2O %	P_2O_5 %	SiO_2 %	TiO_2 %	Sum oxides %
SSM000224	12.00	13.00	0.09	3.85	0.17	66.60	0.49	99.20
SSM000225	2.00	2.80	0.05	3.35	0.11	73.90	0.46	100.30
PSM006585	4.80	4.82	0.04	2.22	0.21	60.00	0.40	77.30
PSM006563	4.66	4.70	0.04	3.25	0.14	62.90	0.40	86.30
PSM007160	1.00	1.10	0.05	3.82	0.12	68.90	0.30	98.70
PSM007171	1.25	1.25	0.07	3.44	0.22	66.90	0.53	98.70
PSM007180	0.30	0.30	0.04	3.80	0.09	72.40	0.20	100.00
PSM001477			0.07	3.44	0.07	72.80	0.26	99.80

Id-code	From (m)	To (m)	LOI %	Ag mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Cd mg/kg
SSM000224	12.00	13.00	1.30	0.06	0.82	1040	1.90	0.07
SSM000225	2.00	2.80	0.70	0.05	1.05	812	0.73	0.06
PSM006585	4.80	4.82	23.00	0.29	4.14	380	1.60	1.02
PSM006563	4.66	4.70		–	2.81	594	3.99	0.04
PSM007160	1.00	1.10	1.20	0.05	2.22	1030	0.89	0.04
PSM007171	1.25	1.25	2.00	0.04	3.21	994	1.15	0.04
PSM007180	0.30	0.30	0.50	–	1.20	945	0.72	0.04
PSM001477			0.20	0.64	1.13	808	3.24	0.02

Id-code	From (m)	To (m)	Co mg/kg	Cr mg/kg	Cs mg/kg	Cu mg/kg	Ga mg/kg	Hf mg/kg	Hg mg/kg
SSM000224	12.00	13.00	9.3	56.9	1.6	16.5	15.0	3.74	–0.04
SSM000225	2.00	2.80	3.5	29.5	0.8	20.1	9.8	5.63	–0.04
PSM006585	4.80	4.82	6.5	36.9	2.7	32.0	–1.0	5.24	–0.04
PSM006563	4.66	4.70	4.3	14.4	2.2	4.1	61.9	5.50	–0.02
PSM007160	1.00	1.10	4.7	46.3	1.7	15.6	11.3	2.70	–0.04
PSM007171	1.25	1.25	7.6	45.5	2.2	11.6	10.6	3.34	–0.04
PSM007180	0.30	0.30	4.8	33.3	1.0	7.2	11.0	2.20	–0.04
PSM001477			4.8	69.5	1.6	15.9	13.3	4.32	–0.05

Sand

Id-code	From (m)	To (m)	Li mg/kg	Mo mg/kg	Nb mg/kg	Ni mg/kg	Pb mg/kg	Rb mg/kg	S mg/kg
SSM000224	12.00	13.00	28.7	1.0	8.3	15.5	8.5	125.0	188
SSM000225	2.00	2.80	12.3	1.6	13.6	8.3	8.0	114.0	77
PSM006585	4.80	4.82	17.6	–	9.1	27.7	12.0	77.8	13200
PSM006563	4.66	4.70	20.6	–	13.6	5.5	15.7	146.0	4960
PSM007160	1.00	1.10	15.5	1.1	6.2	12.6	6.6	96.0	78
PSM007171	1.25	1.25	26.6	2.0	8.5	15.3	5.8	103.0	171
PSM007180	0.30	0.30	16.3	1.7	4.8	9.5	5.7	140.0	90
PSM001477			10.1	5.3	11.1	13.0	13.8	143.0	1980

Id-code	From (m)	To (m)	Sb mg/kg	Sc mg/kg	Sn mg/kg	Sr mg/kg	Ta mg/kg	Th mg/kg	Tl mg/kg
SSM000224	12.00	13.00	–0.04	6.3	0.94	576	0.68	10.60	0.20
SSM000225	2.00	2.80	0.05	4.1	1.39	315	0.96	11.80	0.16
PSM006585	4.80	4.82	0.27	4.2	–	180	0.58	9.99	0.53
PSM006563	4.66	4.70	0.23	4.0	1.26	289	0.82	6.97	0.85
PSM007160	1.00	1.10	–0.04	4.6	0.72	581	0.54	8.67	0.18
PSM007171	1.25	1.25	–0.04	7.9	0.81	499	0.67	7.55	0.32
PSM007180	0.30	0.30	–0.04	3.0	0.54	418	0.50	4.98	0.16
PSM001477			0.35	3.7	3.26	317	0.84	6.66	0.64

Id-code	From (m)	To (m)	U mg/kg	V mg/kg	W mg/kg	Y mg/kg	Zn mg/kg	Zr mg/kg	Ce mg/kg
SSM000224	12.00	13.00	3.01	51.3	1.70	16.5	90.0	181	55
SSM000225	2.00	2.80	2.57	37.2	1.97	24.9	29.6	242	72
PSM006585	4.80	4.82	6.40	42.3	–	26.8	57.1	339	67
PSM006563	4.66	4.70	2.82	25.6	0.99	23.1	27.5	287	69
PSM007160	1.00	1.10	1.87	34.2	1.46	15.0	40.4	136	38
PSM007171	1.25	1.25	1.74	70.3	1.09	17.0	67.1	201	41
PSM007180	0.30	0.30	1.07	20.7	0.87	8.5	27.0	89	25
PSM001477			2.04	33.9	1.78	14.4	20.5	95	133

Id-code	From (m)	To (m)	La mg/kg	Pr mg/kg	Nd mg/kg	Sm mg/kg	Eu mg/kg	Gd mg/kg	Tb mg/kg
SSM000224	12.00	13.00	25.3	6.3	26.2	3.9	0.4	2.4	0.4
SSM000225	2.00	2.80	32.1	8.6	31.2	4.6	0.7	3.3	0.7
PSM006585	4.80	4.82	22.5	8.3	31.6	4.3	1.0	3.7	0.7
PSM006563	4.66	4.70	30.5	10.8	31.7	5.5	1.2	4.4	0.3
PSM007160	1.00	1.10	18.6	4.3	16.1	2.6	0.4	2.9	0.3
PSM007171	1.25	1.25	18.5	4.9	21.3	2.8	0.6	2.1	0.4
PSM007180	0.30	0.30	13.5	2.4	11.3	1.5	0.2	1.4	0.2
PSM001477			32.0	6.3	22.2	3.8	0.8	3.0	0.5

Sand

Id-code	From (m)	To (m)	Dy mg/kg	Ho mg/kg	Er mg/kg	Tm mg/kg	Yb mg/kg	Lu mg/kg	TS
SSM000224	12.00	13.00	2.27	0.44	0.91	0.18	1.01	0.19	94.7
SSM000225	2.00	2.80	3.19	0.69	1.46	0.35	2.20	0.37	87.6
PSM006585	4.80	4.82	3.87	0.70	2.39	0.38	2.54	0.40	23.4
PSM006563	4.66	4.70	3.97	0.87	2.87	0.52	2.17	0.33	75.2
PSM007160	1.00	1.10	1.60	0.37	1.33	0.21	1.46	0.10	92.0
PSM007171	1.25	1.25	2.00	0.37	1.02	0.14	1.44	0.20	88.7
PSM007180	0.30	0.30	1.04	0.27	0.57	0.17	0.83	0.14	95.3
PSM001477			2.67	0.54	1.47	0.22	1.45	0.26	81.5

Id-code	From (m)	To (m)	Ash%	Cl mg/kg	I mg/kg	N mg/kg	Org. N mg/kg	PO_4 mg/kg
SSM000224	12.00	13.00		53	–	340	290	38
SSM000225	2.00	2.80		60	–	200	160	53
PSM006585	4.80	4.82		12600	12.20	19200	18500	241
PSM006563	4.66	4.70	98.9	366	–	1030	851	40
PSM007160	1.00	1.10		63	–	510	470	61
PSM007171	1.25	1.25		42	–	590	550	129
PSM007180	0.30	0.30		59	–	470	440	41
PSM001477				90	–	–	–	

Clay gyttja

Results from chemical analyses of 33 samples from clay gyttja.

Id-code	From (m)	To (m)	Org. C mg/kg	Al_2O_3 %	CaO %	Fe_2O_3 %	K_2O %	MgO %
PSM006562	4.00	4.10	180,000	3.7	1.00	1.99	0.68	0.47
PSM006562	4.20	4.25	100,000	7.6	0.78	4.12	1.79	1.08
PSM006562	4.35	4.40	64,000	9.4	0.79	4.33	2.29	1.38
PSM006563	0.12	0.15	380,000	1.1	0.88	0.71	0.10	0.14
PSM006563	0.95	1.00	160,000	5.0	1.74	7.68	0.47	0.69
PSM006563	1.97	2.00	170,000	4.1	1.68	3.02	0.76	0.95
PSM006563	2.97	3.00	130,000	4.5	1.40	2.30	1.10	1.02
PSM006563	4.64	4.66	31,000	8.1	1.03	1.89	2.69	0.68
PSM006571	0.00	0.02	120,000	5.7	1.14	4.31	0.68	0.54
PSM006571	0.02	0.04	97,000	5.7	1.12	4.50	0.68	0.53
PSM006571	0.04	0.06	84,000	5.7	1.11	4.50	0.70	0.53
PSM006571	0.06	0.08	110,000	5.7	1.09	4.26	0.68	0.52
PSM006571	0.08	0.10	110,000	5.8	1.51	4.43	0.70	0.57
PSM006571	0.25	0.28	130,000	3.5	1.37	3.87	0.46	0.81
PSM006571	0.48	0.50	130,000	3.9	1.50	2.45	0.50	0.79
PSM006571	0.98	1.00	140,000	6.7	0.97	4.33	0.81	0.60
PSM006571	1.97	2.00	110,000	3.6	0.90	2.39	0.65	1.00
PSM006571	2.97	3.00	100,000	3.3	1.71	2.93	0.68	1.22
PSM006571	3.97	4.00	140,000	2.8	1.19	1.61	0.72	1.31
PSM006571	4.37	4.40	120,000	2.7	1.01	1.51	0.71	1.18
PSM006585	0.00	0.02	94,000	4.6	1.08	3.42	0.95	1.48
PSM006585	0.02	0.04	86,000	4.7	0.90	3.19	0.92	1.45
PSM006585	0.04	0.06	83,000	4.7	0.85	3.27	0.91	1.49
PSM006585	0.06	0.08	82,000	4.7	0.83	3.71	0.91	1.47
PSM006585	0.08	0.10	100,000	4.8	0.84	3.85	0.92	1.45
PSM006585	0.97	1.00	99,000	5.5	1.03	5.01	1.25	1.54
PSM006585	1.97	2.00	120,000	4.9	1.18	3.37	1.19	1.68
PSM006585	2.97	3.00	94,000	4.3	0.92	2.14	1.15	1.35
PSM006585	3.97	4.00	120,000	3.6	0.89	1.94	0.97	1.18
PSM007160	0.70	0.80	5,700	12.4	1.20	6.43	2.86	1.74
PSM007190	1.10	1.30	180,000	3.3	1.77	1.92	0.82	0.58
PSM007171	0.50	0.50	–	5.6	0.30	2.04	1.32	0.52
PSM001477			160,000	5.0	2.02	4.80	1.56	1.05

Clay gyttja

Results from chemical analyses of the 33 samples from clay gyttja.

Id-code	From (m)	To (m)	MnO %	Na_2O %	P_2O_5 %	SiO_2 %	TiO_2 %	Sum oxides %
PSM006562	4.00	4.10	0.02	0.30	0.06	35.10	0.13	43.50
PSM006562	4.20	4.25	0.03	0.90	0.05	58.10	0.28	74.70
PSM006562	4.35	4.40	0.03	1.13	0.05	64.10	0.35	83.90
PSM006563	0.12	0.15	0.00	0.06	0.21	5.50	0.01	8.70
PSM006563	0.95	1.00	0.03	0.39	0.70	36.50	0.11	53.30
PSM006563	1.97	2.00	0.02	0.59	0.26	42.10	0.14	53.60
PSM006563	2.97	3.00	0.02	0.71	0.19	54.50	0.19	65.90
PSM006563	4.64	4.66	0.03	1.93	0.11	64.50	0.22	81.20
PSM006571	0.00	0.02	0.03	0.32	0.36	41.20	0.18	54.40
PSM006571	0.02	0.04	0.04	0.31	0.37	42.30	0.18	55.80
PSM006571	0.04	0.06	0.03	0.30	0.38	41.50	0.18	55.00
PSM006571	0.06	0.08	0.03	0.29	0.36	41.50	0.18	54.70
PSM006571	0.08	0.10	0.03	0.34	0.37	42.90	0.20	56.80
PSM006571	0.25	0.28	0.03	0.66	0.64	38.30	0.09	49.70
PSM006571	0.48	0.50	0.03	0.45	0.70	26.40	0.13	36.90
PSM006571	0.98	1.00	0.03	0.35	0.37	45.80	0.21	60.10
PSM006571	1.97	2.00	0.01	0.91	0.28	48.40	0.12	58.20
PSM006571	2.97	3.00	0.02	1.17	0.34	30.10	0.18	41.70
PSM006571	3.97	4.00	0.01	1.28	0.30	36.30	0.12	45.60
PSM006571	4.37	4.40	0.01	1.28	0.33	44.50	0.12	53.40
PSM006585	0.00	0.02	0.02	3.60	0.36	39.80	0.14	55.40
PSM006585	0.02	0.04	0.02	3.13	0.43	41.10	0.15	56.00
PSM006585	0.04	0.06	0.02	3.30	0.48	41.10	0.15	56.20
PSM006585	0.06	0.08	0.02	3.29	0.37	41.60	0.14	57.00
PSM006585	0.08	0.10	0.02	3.26	0.33	42.50	0.15	58.10
PSM006585	0.97	1.00	0.03	2.26	0.27	45.80	0.22	62.90
PSM006585	1.97	2.00	0.02	2.46	0.26	40.60	0.20	55.90
PSM006585	2.97	3.00	0.02	1.87	0.31	51.40	0.19	63.70
PSM006585	3.97	4.00	0.02	1.77	0.20	49.90	0.17	60.70
PSM007160	0.70	0.80	0.05	1.35	0.06	67.80	0.48	94.40
PSM007190	1.10	1.30	0.02	0.38	0.19	38.00	0.13	47.10
PSM007171	0.50	0.50	0.02	0.60	0.10	77.80	0.29	88.60
PSM001477			0.06	0.61	0.21	26.90	0.23	42.40

Clay gyttja

Results from chemical analyses of the 33 samples from clay gyttja.

Id-code	From (m)	To (m)	LOI %	Ag mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Cd mg/kg
PSM006562	4.00	4.10		–	5.49	176	1.12	0.46
PSM006562	4.20	4.25		–	10.20	333	1.61	0.35
PSM006562	4.35	4.40		–	9.59	407	1.98	0.34
PSM006563	0.12	0.15		–	1.19	28	3.11	0.96
PSM006563	0.95	1.00		–	3.77	131	3.55	1.42
PSM006563	1.97	2.00		–	10.30	120	1.95	0.61
PSM006563	2.97	3.00		–	9.47	171	1.35	0.51
PSM006563	4.64	4.66		–	2.10	565	2.75	0.09
PSM006571	0.00	0.02	39.70	–	4.42	181	8.73	3.47
PSM006571	0.02	0.04	40.00	–	4.35	185	8.82	3.47
PSM006571	0.04	0.06	39.80	–	4.41	187	9.00	3.53
PSM006571	0.06	0.08	40.00	–	4.46	192	9.18	3.62
PSM006571	0.08	0.10	38.90	0.27	4.66	206	9.34	3.52
PSM006571	0.25	0.28	46.20	–	3.51	82	4.57	1.10
PSM006571	0.48	0.50	57.60	–	2.24	155	4.82	1.29
PSM006571	0.98	1.00	36.30	–	5.46	194	9.94	4.44
PSM006571	1.97	2.00	35.80	–	8.51	80	2.29	0.92
PSM006571	2.97	3.00	45.90	–	15.20	137	1.52	1.28
PSM006571	3.97	4.00	47.60	–	16.60	89	1.17	1.35
PSM006571	4.37	4.40	42.50	–	13.90	91	1.03	1.10
PSM006585	0.00	0.02	41.00	–	4.96	100	2.57	2.15
PSM006585	0.02	0.04	39.90	–	5.62	98	2.68	2.24
PSM006585	0.04	0.06	28.80	–	6.18	98	2.67	2.27
PSM006585	0.06	0.08	40.20	–	5.94	98	2.71	2.18
PSM006585	0.08	0.10	40.70	–	6.40	98	2.84	2.38
PSM006585	0.97	1.00	32.60	–	9.48	155	1.65	0.41
PSM006585	1.97	2.00	40.50	–	7.95	152	0.84	0.52
PSM006585	2.97	3.00	32.40	–	10.40	170	1.17	1.04
PSM006585	3.97	4.00	33.70	0.11	10.60	151	1.12	1.26
PSM007160	0.70	0.80	6.40	0.08	6.88	473	2.08	0.08
PSM007190	1.10	1.30	38.40	0.20	6.45	131	1.38	0.88
PSM007171	0.50	0.50	10.50	0.05	1.55	218	1.01	0.11
PSM001477			39.90	1.36	8.22	206	1.43	0.60

Clay gyttja

Results from chemical analyses of the 33 samples from clay gyttja.

Id-code	From (m)	To (m)	Co mg/kg	Cr mg/kg	Cs mg/kg	Cu mg/kg	Ga mg/kg	Hf mg/kg	Hg mg/kg
PSM006562	4.00	4.10	11.6	29.7	1.8	28.6	18.6	1.05	0.03
PSM006562	4.20	4.25	8.5	44.5	3.9	42.1	36.5	1.60	–
PSM006562	4.35	4.40	9.1	55.5	4.9	46.5	29.5	2.20	–
PSM006563	0.12	0.15	3.8	4.2	–0.3	10.5	5.8	0.14	0.06
PSM006563	0.95	1.00	9.6	29.6	1.4	48.6	38.7	1.11	0.04
PSM006563	1.97	2.00	3.2	28.9	1.7	67.0	34.2	0.83	0.02
PSM006563	2.97	3.00	4.6	31.0	2.3	41.4	37.1	0.83	–
PSM006563	4.64	4.66	4.0	23.8	2.4	7.5	58.5	1.51	–
PSM006571	0.00	0.02	22.2	36.6	2.2	66.4	67.6	0.83	0.15
PSM006571	0.02	0.04	21.1	43.5	2.1	64.1	60.2	0.99	0.19
PSM006571	0.04	0.06	23.3	41.7	2.2	61.7	–	1.52	0.19
PSM006571	0.06	0.08	21.2	38.8	2.2	64.6	–	1.34	0.18
PSM006571	0.08	0.10	23.4	41.6	2.3	63.5	6.4	1.91	0.17
PSM006571	0.25	0.28	6.5	23.4	1.1	57.0	–	0.23	0.04
PSM006571	0.48	0.50	12.7	34.7	1.5	63.4	–	0.48	0.07
PSM006571	0.98	1.00	25.4	38.8	2.8	60.5	20.5	1.01	0.11
PSM006571	1.97	2.00	3.0	25.9	1.3	46.8	–	0.35	–
PSM006571	2.97	3.00	2.7	41.7	1.5	62.1	–	–0.10	–
PSM006571	3.97	4.00	3.0	22.5	1.4	55.9	–	–0.10	–
PSM006571	4.37	4.40	3.1	22.1	1.4	47.3	–	–0.10	–
PSM006585	0.00	0.02	9.0	25.8	1.8	58.3	–	0.22	0.09
PSM006585	0.02	0.04	10.3	22.4	1.9	63.9	–	0.81	0.09
PSM006585	0.04	0.06	11.7	25.7	1.8	68.7	–	0.90	0.09
PSM006585	0.06	0.08	12.4	29.6	1.8	61.7	–	0.70	0.07
PSM006585	0.08	0.10	12.5	27.5	1.8	60.6	–	0.56	0.09
PSM006585	0.97	1.00	4.6	34.9	2.5	42.6	–	1.12	–
PSM006585	1.97	2.00	2.6	38.7	1.4	55.7	–	0.79	–
PSM006585	2.97	3.00	4.5	31.7	2.3	51.1	–	0.29	–
PSM006585	3.97	4.00	4.1	30.6	2.0	48.8	–	0.53	–
PSM007160	0.70	0.80	11.7	79.6	5.8	39.8	4.6	2.37	–
PSM007190	1.10	1.30	3.0	28.0	1.5	55.2	–	0.82	0.08
PSM007171	0.50	0.50	3.2	54.0	3.4	43.3	–	1.41	0.04
PSM001477			7.4	70.1	2.6	53.3	7.2	2.10	0.07

Clay gyttja

Results from chemical analyses of the 33 samples from clay gyttja.

Id-code	From (m)	To (m)	Li mg/kg	Mo mg/kg	Nb mg/kg	Ni mg/kg	Pb mg/kg	Rb mg/kg	S mg/kg
PSM006562	4.00	4.10	11.6	3.4	3.3	26.4	6.1	35.6	7680
PSM006562	4.20	4.25	22.8	7.1	6.9	31.5	12.6	94.1	16200
PSM006562	4.35	4.40	29.5	7.4	8.5	30.1	15.1	108.0	10900
PSM006563	0.12	0.15	1.2	1.7	0.5	12.9	19.9	3.3	8910
PSM006563	0.95	1.00	12.7	6.2	3.8	33.1	9.5	26.4	67600
PSM006563	1.97	2.00	11.9	13.9	3.8	35.4	9.7	37.6	34100
PSM006563	2.97	3.00	15.8	8.9	4.9	29.2	8.7	51.8	20900
PSM006563	4.64	4.66	20.7	3.1	7.1	6.3	13.2	109.0	5010
PSM006571	0.00	0.02	19.6	–	–	52.0	42.7	39.7	18500
PSM006571	0.02	0.04	19.4	–	–	51.9	40.7	40.7	17500
PSM006571	0.04	0.06	20.0	–	–	54.7	42.8	36.8	16700
PSM006571	0.06	0.08	20.4	–	–	52.0	43.3	35.8	19600
PSM006571	0.08	0.10	20.9	–	–	53.9	46.1	42.1	19000
PSM006571	0.25	0.28	6.7	23.9	–	28.6	6.0	22.8	40900
PSM006571	0.48	0.50	8.9	–	–	31.1	13.9	28.6	24000
PSM006571	0.98	1.00	22.6	–	–	71.6	39.0	50.7	24000
PSM006571	1.97	2.00	8.4	11.0	–	25.5	7.3	32.3	24600
PSM006571	2.97	3.00	9.1	14.7	–	32.9	6.4	34.4	26700
PSM006571	3.97	4.00	9.0	12.0	–	36.2	5.6	23.7	25600
PSM006571	4.37	4.40	9.0	9.2	–	32.1	5.4	22.1	22000
PSM006585	0.00	0.02	29.6	–	–	30.4	24.4	29.6	28800
PSM006585	0.02	0.04	32.5	–	–	34.6	25.4	30.3	29700
PSM006585	0.04	0.06	31.9	6.1	–	37.0	24.8	25.9	27900
PSM006585	0.06	0.08	33.9	6.2	–	35.6	25.5	25.3	29600
PSM006585	0.08	0.10	36.3	6.6	–	36.3	27.9	33.6	30100
PSM006585	0.97	1.00	16.0	–	–	25.0	17.5	51.5	38500
PSM006585	1.97	2.00	9.6	9.1	–	35.0	7.6	50.7	28800
PSM006585	2.97	3.00	14.2	–	–	35.4	8.1	53.5	17700
PSM006585	3.97	4.00	12.4	9.4	–	37.3	7.6	45.0	18000
PSM007160	0.70	0.80	28.7	0.4	11.0	27.6	15.2	107.0	150
PSM007190	1.10	1.30	9.2	8.7	0.4	26.1	6.8	26.7	19700
PSM007171	0.50	0.50	11.8	2.1	4.2	10.4	8.6	37.6	806
PSM001477			13.6	20.9	2.0	35.2	9.3	59.8	23200

Clay gyttja

Results from chemical analyses of the 33 samples from clay gyttja.

Id-code	From (m)	To (m)	Sb mg/kg	Sc mg/kg	Sn mg/kg	Sr mg/kg	Ta mg/kg	Th mg/kg	Tl mg/kg
PSM006562	4.00	4.10	0.19	4.7	–	57	0.12	6.61	0.34
PSM006562	4.20	4.25	0.43	7.3	1.07	77	0.34	8.20	0.61
PSM006562	4.35	4.40	0.69	7.5	–	83	0.42	9.70	0.75
PSM006563	0.12	0.15	0.19	1.1	0.43	59	0.02	0.94	0.15
PSM006563	0.95	1.00	0.14	6.3	–	193	0.20	9.61	0.47
PSM006563	1.97	2.00	0.42	5.3	–	171	0.14	8.04	0.28
PSM006563	2.97	3.00	0.38	5.0	1.02	146	0.23	6.74	0.35
PSM006563	4.64	4.66	0.18	4.1	2.16	211	0.52	5.51	0.74
PSM006571	0.00	0.02	0.79	7.7	–	67	–0.06	9.90	0.61
PSM006571	0.02	0.04	0.62	8.4	–	67	–0.06	10.10	0.56
PSM006571	0.04	0.06	0.63	8.1	–	65	0.43	10.00	0.57
PSM006571	0.06	0.08	0.66	8.6	–	63	0.89	9.79	0.57
PSM006571	0.08	0.10	0.75	7.6	–	72	0.22	9.53	0.58
PSM006571	0.25	0.28	0.20	6.2	–	123	–0.06	8.23	0.36
PSM006571	0.48	0.50	0.21	7.1	–	120	–0.06	7.99	0.40
PSM006571	0.98	1.00	0.94	8.3	–	61	0.26	9.37	0.61
PSM006571	1.97	2.00	0.19	5.4	–	104	–0.06	6.36	0.25
PSM006571	2.97	3.00	0.31	4.5	–	125	–0.06	4.57	0.24
PSM006571	3.97	4.00	0.35	3.5	–	128	–0.06	4.24	0.26
PSM006571	4.37	4.40	0.31	3.6	–	112	–0.06	3.86	0.25
PSM006585	0.00	0.02	0.52	5.5	–	114	–0.06	6.54	0.43
PSM006585	0.02	0.04	0.46	4.8	–	99	0.39	6.91	0.51
PSM006585	0.04	0.06	0.55	6.0	–	99	0.18	6.76	0.50
PSM006585	0.06	0.08	0.62	5.0	–	93	0.24	6.64	0.51
PSM006585	0.08	0.10	0.65	5.0	–	94	0.19	7.01	0.50
PSM006585	0.97	1.00	0.35	6.8	–	117	0.33	8.79	0.31
PSM006585	1.97	2.00	0.39	6.3	–	127	0.27	7.90	0.17
PSM006585	2.97	3.00	0.27	5.1	–	99	0.20	5.86	0.36
PSM006585	3.97	4.00	0.31	4.6	–	97	0.19	4.72	0.35
PSM007160	0.70	0.80	–	11.9	0.56	115	0.89	14.90	0.56
PSM007190	1.10	1.30	0.05	4.0	0.43	90	0.18	6.60	0.20
PSM007171	0.50	0.50	0.04	5.0	0.25	55	0.34	10.00	0.31
PSM001477			0.42	5.9	–	116	0.35	5.45	0.36

Clay gyttja

Results from chemical analyses of the 33 samples from clay gyttja.

Id-code	From (m)	To (m)	U mg/kg	V mg/kg	W mg/kg	Y mg/kg	Zn mg/kg	Zr mg/kg	Ce mg/kg
PSM006562	4.00	4.10	7.91	37.6	0.66	39.1	97.0	40	99
PSM006562	4.20	4.25	19.10	62.9	1.48	13.8	70.3	71	57
PSM006562	4.35	4.40	26.60	77.9	1.26	28.1	64.8	77	59
PSM006563	0.12	0.15	2.19	12.8	0.28	19.3	119.0	5	45
PSM006563	0.95	1.00	14.90	32.4	1.03	84.9	116.0	44	224
PSM006563	1.97	2.00	11.20	27.3	0.87	40.9	60.5	53	85
PSM006563	2.97	3.00	10.00	30.2	1.21	23.0	54.8	62	43
PSM006563	4.64	4.66	3.32	41.3	1.96	14.3	36.7	94	44
PSM006571	0.00	0.02	13.00	42.5	–	83.2	233.0	58	222
PSM006571	0.02	0.04	13.40	44.0	–	85.4	211.0	69	240
PSM006571	0.04	0.06	12.60	44.2	–	83.4	225.0	59	247
PSM006571	0.06	0.08	12.30	45.4	–	84.5	224.0	67	254
PSM006571	0.08	0.10	12.00	44.4	–	79.7	240.0	83	250
PSM006571	0.25	0.28	15.10	27.7	–	68.2	91.0	34	231
PSM006571	0.48	0.50	13.20	36.4	–	75.2	106.0	56	259
PSM006571	0.98	1.00	12.40	48.1	–	81.9	229.0	58	255
PSM006571	1.97	2.00	9.96	26.6	–	41.1	54.7	55	140
PSM006571	2.97	3.00	12.40	25.0	–	31.0	59.7	38	79
PSM006571	3.97	4.00	15.20	23.7	–	20.9	50.1	45	41
PSM006571	4.37	4.40	12.70	22.5	–	22.8	45.1	36	38
PSM006585	0.00	0.02	4.92	32.3	–	54.6	190.0	43	123
PSM006585	0.02	0.04	5.52	30.6	–	57.0	183.0	45	132
PSM006585	0.04	0.06	5.89	34.9	–	54.5	184.0	45	129
PSM006585	0.06	0.08	7.12	34.2	–	56.9	184.0	44	131
PSM006585	0.08	0.10	7.25	35.4	–	58.9	198.0	46	148
PSM006585	0.97	1.00	6.57	37.3	–	45.8	53.7	72	142
PSM006585	1.97	2.00	7.61	36.4	–	35.7	31.8	63	94
PSM006585	2.97	3.00	12.00	33.8	–	22.7	49.8	57	48
PSM006585	3.97	4.00	8.95	29.5	–	20.8	45.8	60	44
PSM007160	0.70	0.80	2.70	83.5	2.09	35.9	94.9	111	67
PSM007190	1.10	1.30	6.82	19.4	1.59	24.7	47.6	34	56
PSM007171	0.50	0.50	6.26	32.5	0.90	10.2	23.9	93	22
PSM001477			16.20	47.1	1.75	25.0	60.4	73	71

Clay gyttja

Results from chemical analyses of the 33 samples from clay gyttja.

Id-code	From (m)	To (m)	La mg/kg	Pr mg/kg	Nd mg/kg	Sm mg/kg	Eu mg/kg	Gd mg/kg	Tb mg/kg
PSM006562	4.00	4.10	52.4	13.9	54.1	9.4	1.6	7.8	0.9
PSM006562	4.20	4.25	29.7	8.9	30.2	5.6	0.8	3.9	0.3
PSM006562	4.35	4.40	28.4	8.7	30.5	5.8	0.8	4.0	0.4
PSM006563	0.12	0.15	26.1	6.1	22.8	3.7	0.6	3.4	0.4
PSM006563	0.95	1.00	123.0	31.1	115.0	18.6	3.2	16.8	2.1
PSM006563	1.97	2.00	44.9	13.3	44.9	8.1	1.3	7.5	0.9
PSM006563	2.97	3.00	21.3	7.5	23.2	4.1	0.8	4.2	0.3
PSM006563	4.64	4.66	16.5	6.2	15.0	3.1	0.5	2.3	–0.1
PSM006571	0.00	0.02	116.0	32.4	119.0	19.3	3.6	16.6	2.0
PSM006571	0.02	0.04	118.0	34.8	127.0	20.7	3.7	17.2	2.2
PSM006571	0.04	0.06	117.0	31.6	131.0	20.6	3.7	16.6	2.3
PSM006571	0.06	0.08	126.0	32.1	128.0	21.6	3.6	16.8	2.3
PSM006571	0.08	0.10	114.0	33.5	133.0	20.9	3.7	15.8	2.3
PSM006571	0.25	0.28	99.2	28.0	111.0	16.6	3.1	13.5	1.9
PSM006571	0.48	0.50	116.0	33.4	131.0	21.7	3.8	16.2	2.3
PSM006571	0.98	1.00	131.0	34.8	131.0	21.8	3.9	15.7	2.3
PSM006571	1.97	2.00	64.1	18.1	68.6	10.1	2.0	8.4	1.2
PSM006571	2.97	3.00	43.5	11.1	44.2	6.7	1.3	5.8	0.8
PSM006571	3.97	4.00	15.0	4.8	23.4	3.5	0.6	3.6	0.5
PSM006571	4.37	4.40	13.1	4.6	21.8	2.8	0.5	3.5	0.4
PSM006585	0.00	0.02	65.4	16.4	68.7	10.7	1.8	9.2	1.3
PSM006585	0.02	0.04	69.0	17.5	71.8	10.9	1.7	8.4	1.4
PSM006585	0.04	0.06	76.1	15.5	73.2	10.7	1.8	8.9	1.3
PSM006585	0.06	0.08	68.1	15.6	70.5	9.5	1.6	8.8	1.3
PSM006585	0.08	0.10	74.6	18.5	75.3	11.7	2.1	11.0	1.5
PSM006585	0.97	1.00	69.1	18.5	74.9	11.0	1.9	8.9	1.3
PSM006585	1.97	2.00	42.4	12.9	52.7	8.3	1.3	6.9	1.0
PSM006585	2.97	3.00	21.3	6.6	27.4	4.3	0.9	3.3	0.5
PSM006585	3.97	4.00	22.6	6.4	24.5	3.4	0.7	3.6	0.4
PSM007160	0.70	0.80	36.9	9.4	39.2	5.7	0.9	4.0	1.0
PSM007190	1.10	1.30	28.5	7.1	32.3	4.3	0.8	3.2	0.6
PSM007171	0.50	0.50	11.3	2.1	11.8	1.3	0.2	1.2	0.2
PSM001477			34.4	7.3	28.1	5.0	0.9	4.6	0.6

Clay gyttja

Results from chemical analyses of the 33 samples from clay gyttja.

Id-code	From (m)	To (m)	Dy mg/kg	Ho mg/kg	Er mg/kg	Tm mg/kg	Yb mg/kg	Lu mg/kg	TS
PSM006562	4.00	4.10	5.97	1.22	3.60	0.55	2.98	0.47	93.2
PSM006562	4.20	4.25	3.54	0.86	2.57	0.41	1.94	0.27	95.6
PSM006562	4.35	4.40	4.18	0.96	2.74	0.40	2.45	0.29	96.2
PSM006563	0.12	0.15	2.50	0.56	1.70	0.26	1.48	0.22	8.1
PSM006563	0.95	1.00	12.50	2.61	7.42	1.11	6.74	0.96	11.7
PSM006563	1.97	2.00	6.35	1.32	3.86	0.61	3.23	0.50	16.1
PSM006563	2.97	3.00	3.55	0.81	2.72	0.40	2.21	0.33	17.5
PSM006563	4.64	4.66	2.07	0.54	1.72	0.33	1.27	0.14	46.8
PSM006571	0.00	0.02	11.70	2.52	8.03	1.18	6.65	0.99	14.6
PSM006571	0.02	0.04	13.10	2.76	8.26	1.31	6.98	1.04	11.6
PSM006571	0.04	0.06	12.10	2.43	7.23	1.12	7.48	1.08	10.0
PSM006571	0.06	0.08	11.30	2.40	6.80	1.11	7.51	1.12	12.4
PSM006571	0.08	0.10	11.40	2.24	6.52	1.11	6.79	1.06	13.0
PSM006571	0.25	0.28	9.51	1.89	5.42	0.84	5.52	0.80	10.4
PSM006571	0.48	0.50	11.40	2.17	5.94	0.96	6.46	0.96	10.2
PSM006571	0.98	1.00	10.90	2.35	6.79	1.12	6.76	1.05	10.6
PSM006571	1.97	2.00	6.12	1.27	3.31	0.53	3.63	0.57	17.1
PSM006571	2.97	3.00	4.25	0.87	2.53	0.45	2.77	0.42	18.0
PSM006571	3.97	4.00	3.25	0.63	1.75	0.28	2.04	0.32	17.9
PSM006571	4.37	4.40	2.74	0.51	1.91	0.29	1.89	0.33	20.1
PSM006585	0.00	0.02	7.35	1.47	4.41	0.72	4.92	0.71	9.6
PSM006585	0.02	0.04	7.77	1.49	4.70	0.63	4.61	0.71	3.5
PSM006585	0.04	0.06	7.32	1.38	4.34	0.64	4.82	0.71	17.0
PSM006585	0.06	0.08	7.35	1.38	4.06	0.63	4.41	0.73	8.7
PSM006585	0.08	0.10	7.61	1.46	3.93	0.70	4.36	0.73	8.3
PSM006585	0.97	1.00	6.97	1.26	3.97	0.54	3.78	0.58	16.7
PSM006585	1.97	2.00	5.81	1.01	3.10	0.51	3.01	0.51	17.8
PSM006585	2.97	3.00	3.02	0.63	1.93	0.32	1.96	0.32	20.0
PSM006585	3.97	4.00	3.39	0.56	1.78	0.28	1.60	0.25	21.2
PSM007160	0.70	0.80	4.75	0.92	2.59	0.37	2.48	0.37	60.0
PSM007190	1.10	1.30	3.09	0.64	2.06	0.31	1.99	0.34	24.8
PSM007171	0.50	0.50	1.18	0.20	0.55	–0.10	0.63	0.11	44.5
PSM001477			3.89	0.82	2.52	0.36	2.33	0.40	20.4

Clay gyttja

Results from chemical analyses of the 33 samples from clay gyttja.

Id-code	From (m)	To (m)	Ash%	Cl mg/kg	I mg/kg	N mg/kg	Org. N mg/kg	PO_4 mg/kg
PSM006562	4.00	4.10	46.5	–50	–	15700	14900	19
PSM006562	4.20	4.25	78.3	–50	–	9930	9400	14
PSM006562	4.35	4.40	86.4	–50	–	6440	5990	14
PSM006563	0.12	0.15	10.8	161	–	12500	11900	180
PSM006563	0.95	1.00	60.8	1370	2.13	13900	13300	340
PSM006563	1.97	2.00	59.9	1490	4.86	22400	21400	270
PSM006563	2.97	3.00	70.7	3050	7.35	17300	16600	300
PSM006563	4.64	4.66	92.4	944	1.75	2940	2780	70
PSM006571	0.00	0.02		352	4.25	12700	11000	83
PSM006571	0.02	0.04		236	3.44	14600	12900	80
PSM006571	0.04	0.06		260	4.28	16500	15000	84
PSM006571	0.06	0.08		289	3.60	14500	12400	98
PSM006571	0.08	0.10		239	3.38	16400	14300	118
PSM006571	0.25	0.28		2880	13.50	19300	16900	412
PSM006571	0.48	0.50		1590	6.27	19700	17800	800
PSM006571	0.98	1.00		334	2.44	14400	12700	138
PSM006571	1.97	2.00		4330	22.60	16700	14900	338
PSM006571	2.97	3.00		5420	28.80	22100	21000	524
PSM006571	3.97	4.00		7230	39.00	22900	21400	570
PSM006571	4.37	4.40		7590	40.50	21600	20600	720
PSM006585	0.00	0.02		56500	8.63	16500	14300	454
PSM006585	0.02	0.04		44100	9.60	15700	14600	470
PSM006585	0.04	0.06		44300	9.65	15700	14000	525
PSM006585	0.06	0.08		44800	8.33	16700	15400	442
PSM006585	0.08	0.10		41300	7.20	19000	17400	378
PSM006585	0.97	1.00		21700	7.55	14700	13800	257
PSM006585	1.97	2.00		21700	12.40	17600	16500	188
PSM006585	2.97	3.00		17500	19.50	16600	15700	406
PSM006585	3.97	4.00		15700	20.80	11200	9020	426
PSM007160	0.70	0.80		–	–0.50	1300	1200	25
PSM007190	1.10	1.30		27	4.56	13000	13000	178
PSM007171	0.50	0.50		56	2.83	2500	2300	36
PSM001477				74	7.23	19480	17000	

Peat

Results from chemical analyses of the 5 samples from peat.

Id-code	From (m)	To (m)	Org. C mg/kg	Al_2O_3 %	CaO %	Fe_2O3 %	K_2O %	MgO %
PSM006562	0.05	0.17	420000	0.3	0.11	0.26	0.05	0.08
PSM006562	0.65	0.72	440000	0.1	0.14	0.10	0.01	0.05
PSM006562	2.00	2.10	280000	0.6	0.92	0.48	0.01	0.05
PSM006562	3.40	3.50	250000	0.8	1.67	0.95	0.01	0.08
PSM006562	3.65	3.70	440000	0.8	1.15	0.75	0.01	0.06

Id-code	From (m)	To (m)	MnO %	Na_2O %	P_2O_5 %	SiO_2 %	TiO_2 %	Sum oxides %
PSM006562	0.05	0.17	0.00	0.05	0.07	1.70	0.02	2.70
PSM006562	0.65	0.72	0.00	0.01	0.02	0.40	0.00	0.80
PSM006562	2.00	2.10	0.00	0.01	0.09	0.90	0.02	3.10
PSM006562	3.40	3.50	0.01	0.01	0.08	0.50	0.01	4.10
PSM006562	3.65	3.70	0.01	0.01	0.06	0.60	0.01	3.50

Id-code	From (m)	To (m)	LOI %	Ag mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Cd mg/kg
PSM006562	0.05	0.17		–	2.19	22	0.08	0.41
PSM006562	0.65	0.72		0.22	0.79	8	0.06	0.08
PSM006562	2.00	2.10		–	0.41	59	0.33	0.08
PSM006562	3.40	3.50		–	0.70	63	0.29	0.20
PSM006562	3.65	3.70		–	1.76	42	0.39	0.14

Id-code	From (m)	To (m)	Co mg/kg	Cr mg/kg	Cs mg/kg	Cu mg/kg	Ga mg/kg	Hf mg/kg	Hg mg/kg
PSM006562	0.05	0.17	0.8	6.7	0.1	3.4	2.2	0.10	0.10
PSM006562	0.65	0.72	0.5	0.6	0.1	1.8	0.5	0.03	–
PSM006562	2.00	2.10	1.2	3.8	–	5.3	2.3	0.08	0.05
PSM006562	3.40	3.50	1.0	3.5	0.1	7.4	4.4	0.12	0.04
PSM006562	3.65	3.70	1.3	4.9	–	13.4	3.8	0.20	0.02

Id-code	From (m)	To (m)	Li mg/kg	Mo mg/kg	Nb mg/kg	Ni mg/kg	Pb mg/kg	Rb mg/kg	S mg/kg
PSM006562	0.05	0.17	0.7	0.6	0.4	2.1	22.1	2.1	2630
PSM006562	0.65	0.72	0.6	0.1	0.1	1.2	7.0	0.4	879
PSM006562	2.00	2.10	0.3	0.8	0.3	1.6	1.1	0.9	2160
PSM006562	3.40	3.50	0.3	1.2	0.2	2.8	0.5	1.2	2590
PSM006562	3.65	3.70	0.2	1.8	0.4	6.0	0.7	0.8	3830

Id-code	From (m)	To (m)	Sb mg/kg	Sc mg/kg	Sn mg/kg	Sr mg/kg	Ta mg/kg	Th mg/kg	Tl mg/kg
PSM006562	0.05	0.17	0.71	0.3	0.62	11	0.02	0.35	–0.02
PSM006562	0.65	0.72	0.11	0.1	0.05	9	0.01	0.07	–0.02
PSM006562	2.00	2.10	0.39	1.1	–	45	0.02	0.75	–0.02
PSM006562	3.40	3.50	0.06	1.0	–	56	0.00	1.04	–0.02
PSM006562	3.65	3.70	0.06	0.9	–	39	0.02	1.24	–0.02

Peat

Id-code	From (m)	To (m)	U mg/kg	V mg/kg	W mg/kg	Y mg/kg	Zn mg/kg	Zr mg/kg	Ce mg/kg
PSM006562	0.05	0.17	0.35	2.9	0.13	1.7	25.2	5	5
PSM006562	0.65	0.72	0.08	0.6	0.02	0.4	5.4	1	1
PSM006562	2.00	2.10	1.30	5.2	0.12	7.1	1.8	4	21
PSM006562	3.40	3.50	1.66	11.1	0.16	13.6	2.8	4	42
PSM006562	3.65	3.70	2.09	15.4	0.18	11.9	4.0	5	34

Peat

Results from chemical analyses of the 33 samples from peat.

Id-code	From (m)	To (m)	La mg/kg	Pr mg/kg	Nd mg/kg	Sm mg/kg	Eu mg/kg	Gd mg/kg	Tb mg/kg
PSM006562	0.05	0.17	2.3	0.7	2.2	0.4	0.1	0.3	0.0
PSM006562	0.65	0.72	0.6	0.2	0.5	0.1	0.0	0.1	0.0
PSM006562	2.00	2.10	12.4	2.8	10.1	1.6	0.3	1.4	0.2
PSM006562	3.40	3.50	23.6	5.6	20.1	3.3	0.6	2.8	0.4
PSM006562	3.65	3.70	18.3	4.4	16.7	2.9	0.5	2.4	0.3
Id-code	**From (m)**	**To (m)**	**Dy mg/kg**	**Ho mg/kg**	**Er mg/kg**	**Tm mg/kg**	**Yb mg/kg**	**Lu mg/kg**	**TS**
PSM006562	0.05	0.17	0.28	0.06	0.18	0.03	0.13	0.02	90.8
PSM006562	0.65	0.72	0.07	0.01	0.04	0.01	0.03	0.00	89.7
PSM006562	2.00	2.10	1.03	0.22	0.65	0.09	0.51	0.08	93.1
PSM006562	3.40	3.50	2.07	0.43	1.16	0.18	1.07	0.15	93.2
PSM006562	3.65	3.70	1.80	0.37	1.09	0.17	0.96	0.14	89.5
Id-code	**From (m)**	**To (m)**	**Ash%**	**Cl mg/kg**	**I mg/kg**	**N mg/kg**	**Org. N mg/kg**	**PO_4 mg/kg**	
PSM006562	0.05	0.17	3.0	153	–	7800	6960	94	
PSM006562	0.65	0.72	0.9	122	–	5060	4120	35	
PSM006562	2.00	2.10	3.8	53	–	17500	16200	9	
PSM006562	3.40	3.50	5.1	–50	–	25600	24500	16	
PSM006562	3.65	3.70	4.4	–50	–	16600	15200	17	