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Abstract

The Laxemar subarea is characterised by a relatively flat bedrock surface intersected by a number of narrow topographical lineaments, i.e. valleys. The highest areas are dominated by till and exposed bedrock, whereas the valleys, often used as arable land, are covered by a relatively thick layer of regolith. In many -of the valleys the groundwater table has been lowered by ditches, which has made it possible to use many former wetlands as arable land. Parts of the topographical lineaments may act as discharge area for groundwater from a future deep repository. Geophysical investigations from the area indicate that the bedrock in the topographical lineaments is strongly altered and fractured and is consequently in most parts interpreted as fracture zones.

The most important aims of this investigation were:

1) To characterise the Quaternary deposits and soils in the topographical lineaments by the use of field classification and additional chemical and physical analyses.
2) To describe the properties of the bedrock and possible fracture zones underlying the overburden in the topographical lineaments.
3) To determine if the glaciofluvial deposit, situated in the eastern part of the Laxemar subarea, has significance for the hydrological conditions in the area.

The bedrock was documented in three of the machine dug trenches and consists mainly of Ävrö granite. The bedrock, in all three excavations, showed typical signs of brittle deformation i.e red staining/oxidation of rock groundmass, relatively high fracture frequency and presence of epidote, quartz and chlorite as fracture fillings. The strongest alteration was noted in excavation Profile 4, where the excavation revealed a 12 m long, continuos rock exposure in north-south direction, crosscutting a north-west–south-east trending fracture zone. The central part of the zone, c 4–5 m wide, consists of a strongly fractured and argillic altered bedrock with a c 0.6 m wide core zone of red and green gouge.

The soils and Quaternary deposits were classified and sampled in four machine dug trenches. The Quaternary deposits were described and sampled at two additional sites by the use of soil/rock drillings. The chemical composition, grain size, mineralogy, and hydrological properties of the samples were later analysed. Samples from 10 profiles were included in the analyses of soil properties. These samples were extracted by the use of several methods to determine how the elements are bound in the soils.

All the investigated sites are used or have recently been used as arable land. The localities where the machine cut trenches were made have to a large extent recently been wetlands. At all these sites ditches have lowered the groundwater table.

Soil/rock drillings were made at 29 sites and soil samples were taken from 15 sites. A total of 9 groundwater monitoring wells were installed. The total depth of regolith at the drilled sites varies between 2.8 and 33.6 metres. The largest depth was recorded in a well pronounced valley, which at the investigated site is covered by glaciofluvial material. That material is a part of the glaciofluvial deposit, which is situated, in the eastern part of the Laxemar subarea. It is possible that the glaciofluvial deposit is important for the groundwater properties in the investigated topographical lineaments. The glaciofluvial material has, however, a small surface extension and it is therefore unlikely that it affects the regional groundwater properties.

This and earlier investigations show that the Quaternary deposits in the Laxemar subarea have a similar stratigraphy. The oldest deposit is glacial till, which is lying directly upon the bedrock. The till is overlain by glacial clay, sand/gravel and thereafter gyttja clay. Earlier studies have shown that the gyttja clay often is overlain by peat. The till is at some places well consolidated

and matrix is dominated by sand and gravel. The chemical and mineralogical compositions of the till probably reflect that of the local bedrock. The chemical composition of the youngest water laid sediments partly reflects the relatively nutrient rich conditions, which prevailed in the shallow bays where these sediments once were deposited.

Several soil types were described in the trenches. Regosol (yet not developed to Podzol) is the dominated soil type at two of the sites, whereas Cambisol dominates at another of the studied sites. Peat/gyttja is the prevailing Quaternary deposit at one of the sites and the soil is consequently classified as Histosol at that site.

The physical properties of the soil are characterised by relatively high contents of clay and organic material. That causes relatively low bulk density and high porosity. A high water retention capacity causes small amounts of free water. Low hydraulic conductivity was also recorded. High porosity and conductivity were only recorded in the uppermost soil layer and in the peat/gyttja deposits.

The chemical properties of the soils are to a large extent the effect of the organic and clay contents of the soils. Several of the studied profiles contain clay layers and pH is consequently high especially in the deeper layers but in some cases also in the uppermost soil. The contents of carbon and nitrogen show the normal decreasing trend towards the deeper parts of the soil profiles. Several of the other analysed elements (base cations, Fe, Al and P) show a partly deviating pattern regarding the four investigated trenches. In many samples the analysed elements show higher values than the Swedish average. That is explained by the analyses of many samples taken from fine-grained, clay-rich, arable land, while Sweden to large part is covered by relatively poor till soils. The investigated soils are consequently relatively rich in nutrients.

Sammanfattning

Laxemarområdet kännetecknas av en relativt plan berggrundsyta vilken genomkorsas av ett antal smala topografiska lineament, dvs dalgångar. Höjdområdena domineras av morän och hällmark medan de ofta uppodlade dalgångarna i stor utsträckning täcks av relativt mäktiga jordlager. I de topografiska lineamenten finns områden som kan utgöra utströmningsområden för grundvattnen från ett eventuellt djupförvar. Grundvattenytan i dalstråken har på många platser sänkts genom dikning, vilket gjort det möjligt att använda före detta kärrmarker som åkermark. Resultat från geofysikundersökningar av de topografiska lineamenten indikerar att bergrunden som underlagrar de kvartära avlagringarna vanligtvis är uppsprucken och bedöms utgöra potentiella sprickzoner.

De viktigaste syftena med denna undersökning var;

1) Att med hjälp av fältklassifikationer samt med kemiska och fysikaliska analyser karaktärisera de jordarter och jordmåner som finns i de topografiska lineamenten.
2) Att i maskingrävda schakt frilägga och beskriva berggrunden med avseende på bergarter och eventuella tecken på förekomst av sprickzoner.
3) Att avgöra om den glaciofluviala avlagring, som finns i östra delen av Laxemarområdet, kan ha en betydelse för områdets hydrologi.

Berggrunden kunde dokumenteras i tre av de grävda schakten och utgörs huvudsakligen av Ävrögranit. På samtliga tre platser uppvisar berggrunden tydliga tecken på sprödtektonisk påverkan, såsom rödfärgning/oxidation, relativt hög sprickfrekvens och närvaro av epidot, kvarts och klorit som sprickfyllnader. Den kraftigaste omvandlingen av berggrunden noteras i grävning Profil 4, där en ca 12 m lång bergskärning frilades i nord-sydlig riktning, korsande en nordväst-sydost-gående sprickzon. Den centrala delen av zonen, ca 4–5 m bredd, utgörs av kraftigt uppsprucket och delvis leromvandlat berg. Den centrala delen av zonen, ca 0,6 m bredd, utgörs av helt leromvandlat berg (gouge).

På fyra platser klassificerades och provtogs jordarter och jordmåner i maskingrävda schakt. På ytterligare två platser provtogs och klassificerades jordarterna dessutom med jord/berg borrningar. Jordprover analyserades senare med avseende på kemisk sammansättning, kornstorlek, mineralogi och hydrologiska egenskaper. Totalt ingick prover från 10 profiler i analyserna av jordmånsprover. Dessa prover extraherades med flera metoder för att fastställa hur de olika ämnena är bundna i marken.

Alla undersökta lokaler utom en nyttjas eller har nyligen nyttjats som åkermark. Lokalerna för de maskingrävda schakten har tidigare till stor del varit täckta av våtmarker. På alla dessa lokaler har grundvattenytan sänkts genom dikning.

I 29 punkter utfördes jord/berg sondering och i 15 punkter utfördes jordprovtagning. Totalt installerades 9 grundvattenrör. Jorddjupen i borrhålen varierade mellan 2,8 och 33,6 m. De största jorddjupen finns i en markant dalgång som på den undersökta platsen till stor del fyllts med isälvsmaterial. Detta isälvsmaterial utgör endel av den glaciofluvial avlagring som finns i östra delen av Laxemarområdet. Det är möjligt att isälvssedimenten har en betydelse för dalgångens hydrologi. Isälvsavlagringen har dock en liten utbredning i ytan och den kan knappast påverka grundvattenmönstret över några större områden.

Denna och tidigare undersökningar visar att de kvartära avlagringarna i Laxemar-områdets dalgångar uppvisar en likartad stratigrafi. Den äldsta och närmast berget liggande jordarten är morän som överlagras av glacial lera, sand/grus och därefter lergyttja. Tidigare undersökningar visar att lergyttjan ofta överlagras av torv. Moränen är ibland hårt packad och matrix domineras av grus och sand. Moränens kemiska och mineralogiska sammansättning återspeglar troligen

den lokala bergrundens sammansättning. De yngsta vattenavsatta sedimentens kemiska sammansättning speglar delvis de relativt näringsrika förhållanden som rått i de grunda havsvikar som de en gång avsatts i.

Flera jordmåner klassificerades i schakten. På två av lokalerna är regosol (ännu ej utvecklad till podsol) den dominerande jordmånen, medan cambisol dominerar på en annan av de undersökta platserna. På en lokal är torv/gyttja den förhärskande jordarten vilket lett till att jordmånen klassificerats som histosol.

De markfysikaliska förhållandena visade på relativt högt innehåll av lera och även det organiska innehållet är högt. Detta medför relativt låg skrymdensitet och hög porositet. En hög vattenhållande förmåga medför dock liten volym lättrörligt vatten. Låg hydraulisk konduktivitet har då också blivit följden. Endast ytlagren har en högre porositet och konduktivitet.

De kemiska förhållandena återspeglar till stor del markens innehåll av organiskt material och lera. Eftersom flera av de undersökta profilerna bitvis utgörs av lera är pH ibland högt framförallt i djupare marklager men även nära markytan. Kol- och kväveinnehållet uppvisar den naturliga minskningen med djupet i markprofilen. Däremot visade övriga ämnen (baskatjoner, Fe, Al och P) en delvis varierande bild för de fyra undersökta schakten. De lerrika jordarterna uppvisar de högsta halterna av flera ämnen. Halterna av de analyserade ämnena är i många prover höga i jämförelse med Sverige i övrigt. Detta beror på att proverna kommer från finkornig, lerrik, jordbruksmark medan Sverige till övervägande del karaktäriseras av relativt fattiga moränmarker. De undersökta jordmånerna är därför relativt näringsrika.

Contents

1 Introduction

A general programme for site investigations presenting survey methods has been prepared /SKB 2001a/, as well as a site-specific programme for the geological investigations in the Laxemar area /SKB 2001b/.

Data from altogether five profiles across the narrow topographical lineaments in the Laxemar subarea were obtained within the present study. Additional data from a glaciofluvial deposit is also included. This document report data from bedrock exposures, stratigraphical descriptions of Quaternary deposits (QD), soil classifications and analyses of soil samples gained from machine cut trenches. The studies of soils and QD were carried out in four trenches and the bedrock was studied in three of these trenches. The composition of the vegetation at the four sites has been documented. Results from stratigraphical descriptions and analyses of QD samples gained during soil/rock drillings are also reported. The soil/rock drillings (29 localities) were carried out at the four sites where the machine dug trenches were studied and at two additional sites. At nine of the drilled localities groundwater monitoring wells were installed. The fieldwork was performed in August and September 2005. The samples were analysed during the autumn of 2005 and winter of 2006. The locations of the sites included in this activity were distributed over a part of the Laxemar area (Figure 1-1).

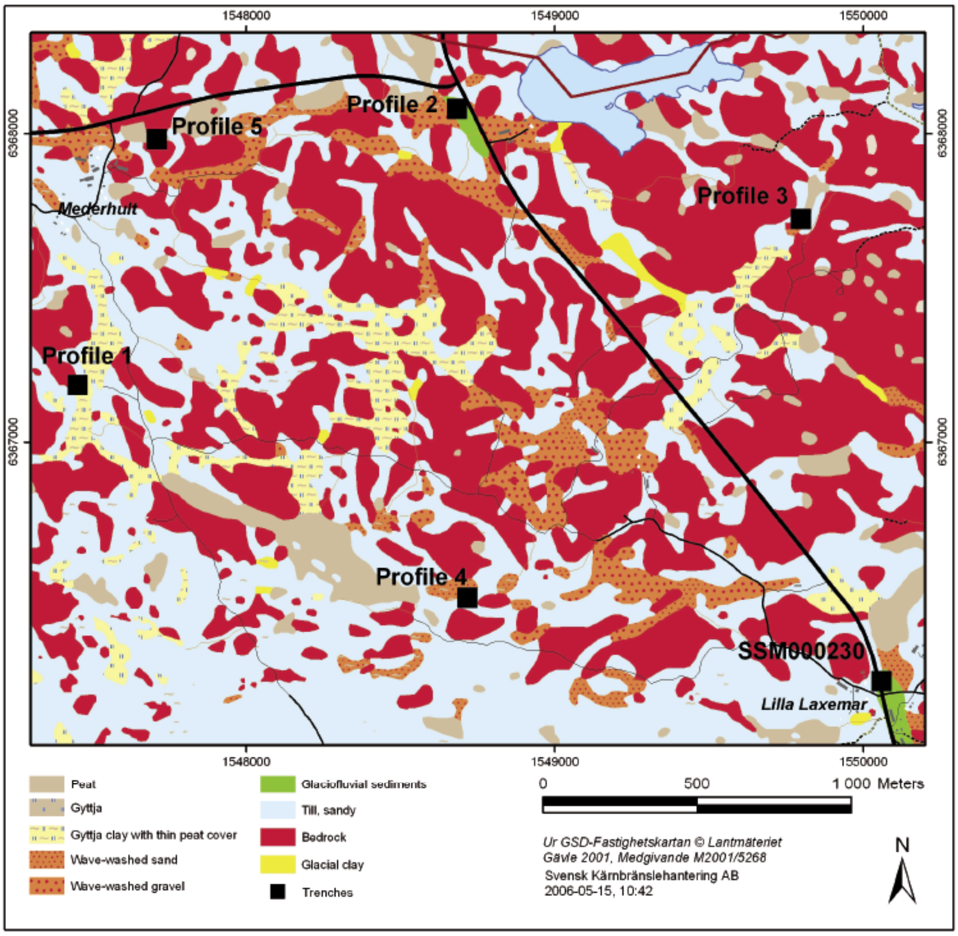


Figure 1-1. *Map showing the location of the investigated profiles and the distribution of Quaternary deposits. SSM000230 is a single point investigation in glaciofluvial sediments located in the south eastern part of the area. The distribution of the investigated points and trenches at the other profiles are shown on the maps below.*

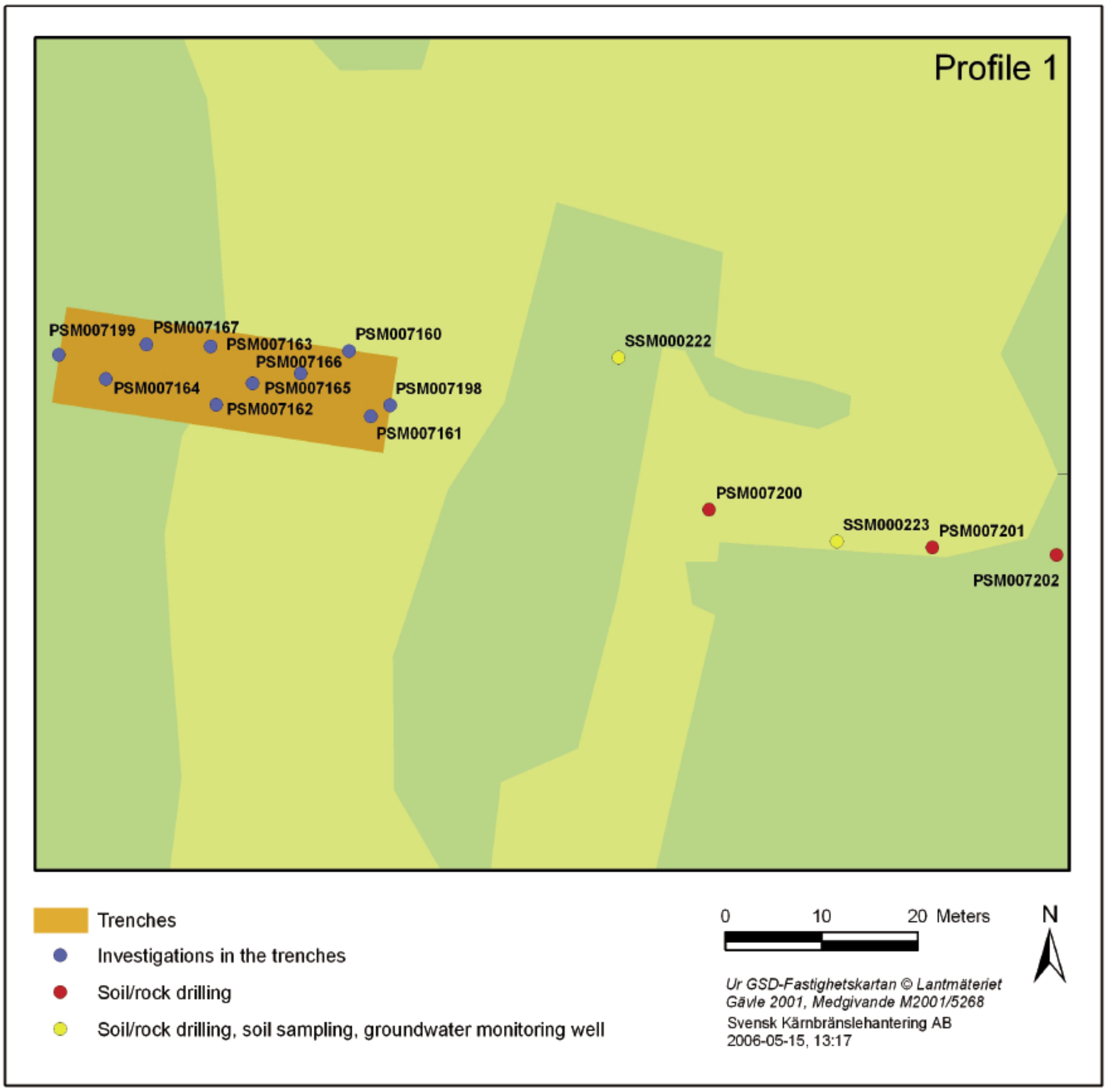


Figure 1-2. *The distribution of investigated sites at Profile 1.*

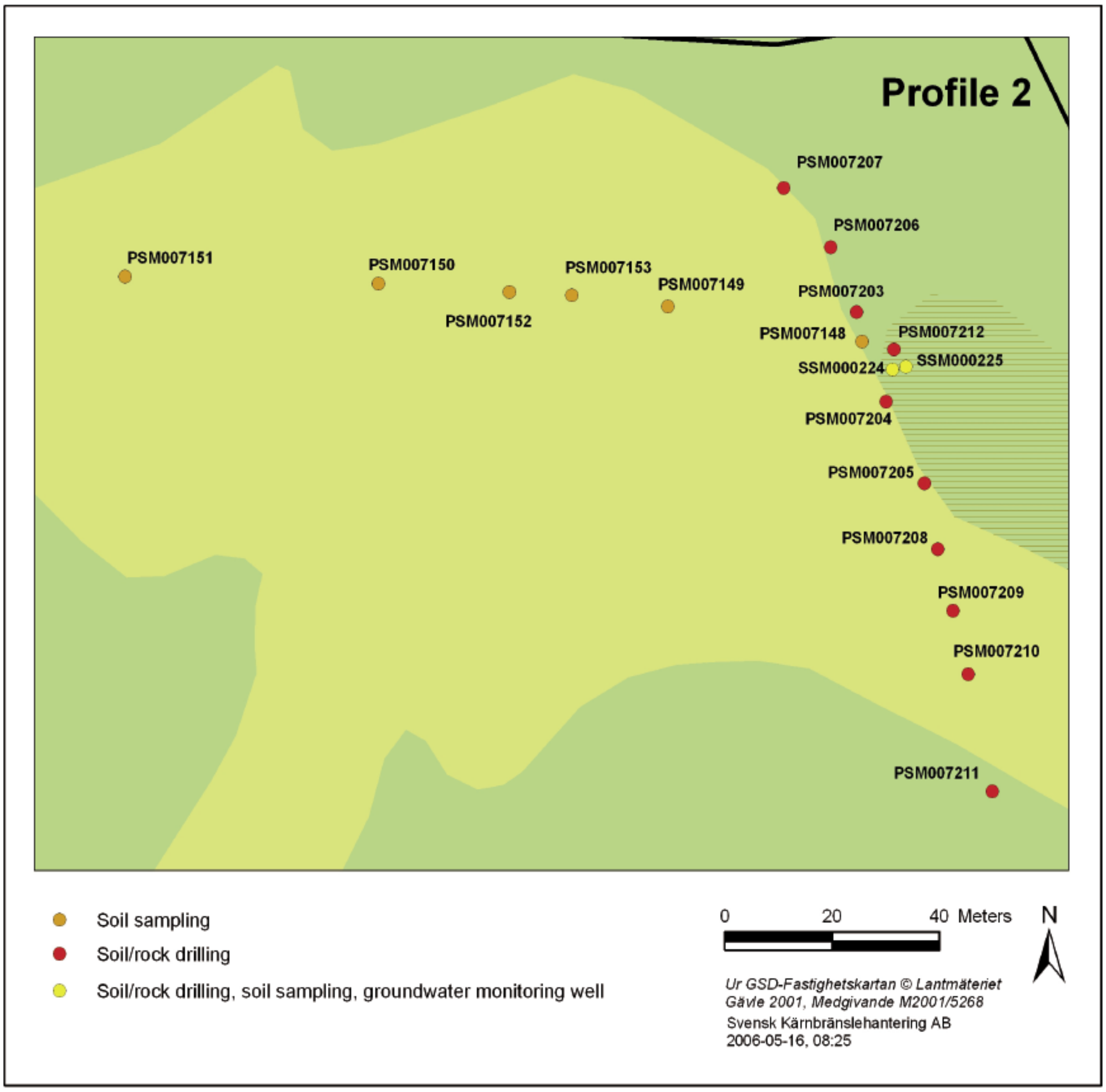


Figure 1-3. *The distribution of investigated sites at Profile 2.*

***Figure 1-4.** The distribution of investigated sites at Profile 3.*

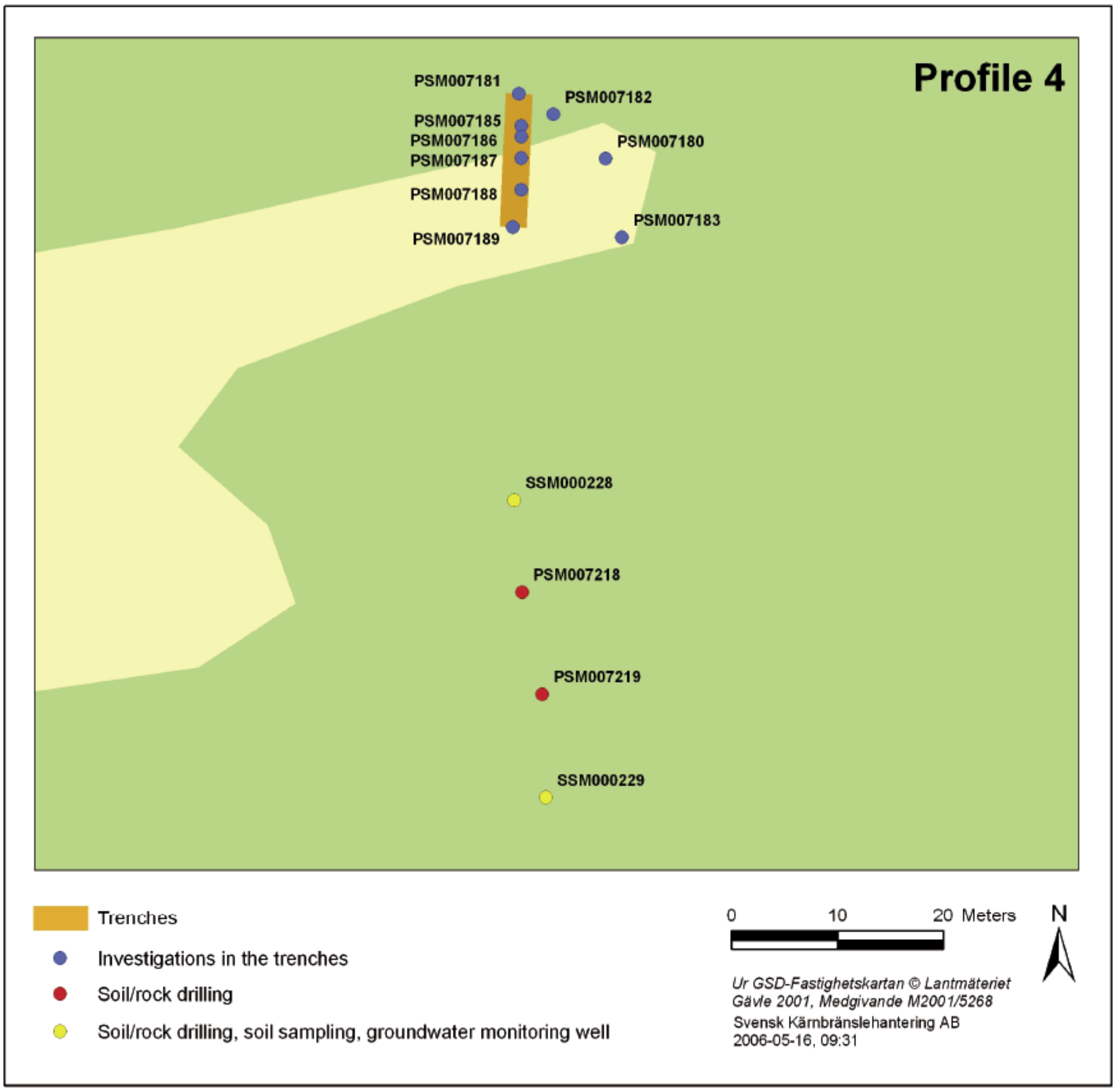


Figure 1-5. *The distribution of investigated sites at Profile 4.*

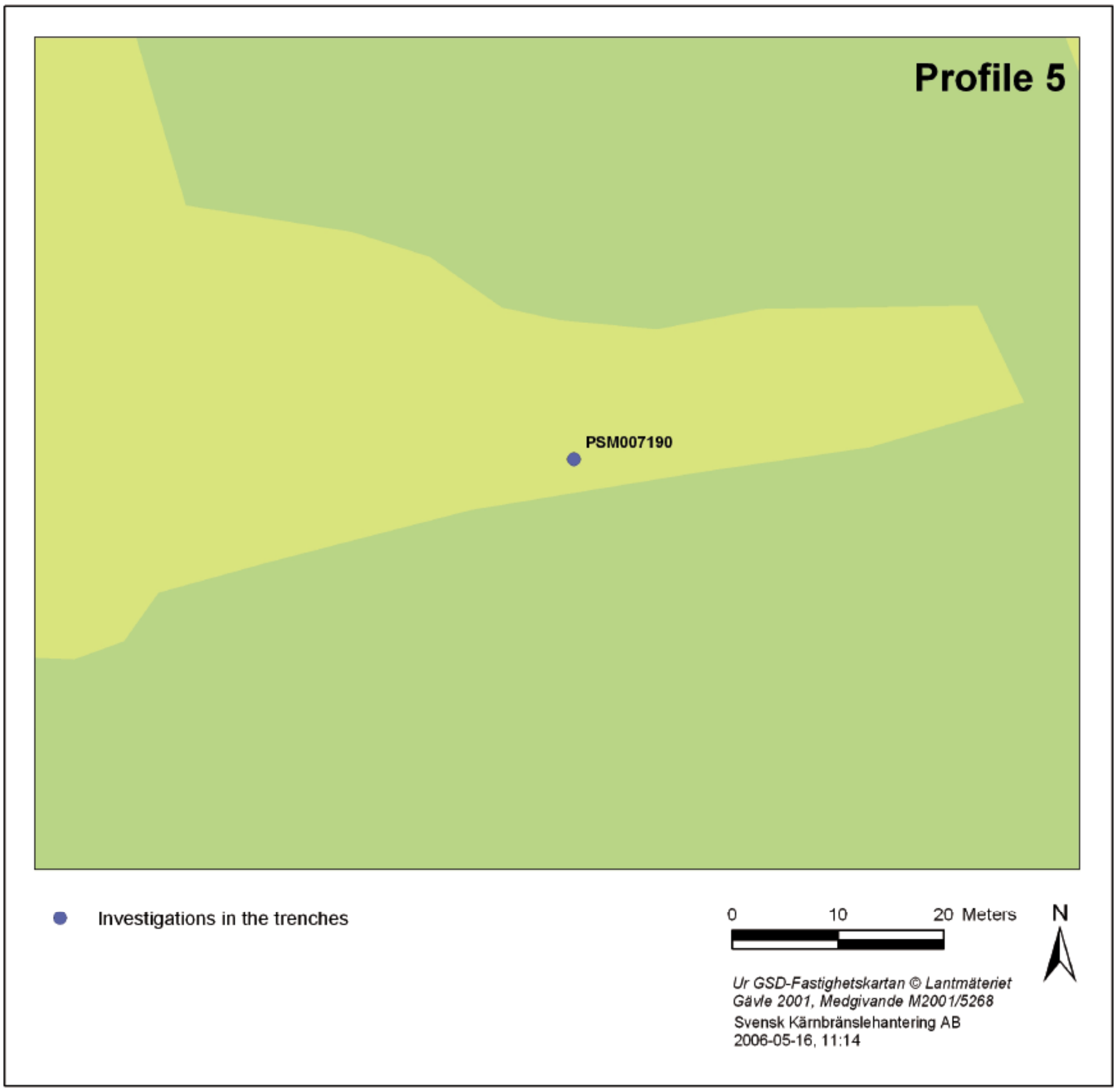


Figure 1-6. *The investigated site at Profile 5.*

The stratigraphical classification of QD (Jordart in Swedish) was carried out by the Geological Survey of Sweden (SGU) whereas the soil (Jordmån in Swedish) classification was made by the Swedish University of Agricultural Sciences (SLU). The chemical composition of the QD, sometimes referred to as soil or regolith, was determined within both these investigations (SGU and SLU).

The analyses of soils (SLU) include soil physical properties such as porosity, bulk and compact densities, soil water retention and hydraulic conductivity. Further, added to this was also sampling for chemical analyses of pH, C, N, exchangeable base cations, extractable potassium and phosphorus, titratable acidity and determination of Fe, Al, Mn and base cations in *Aqua Regia*.

The analyses of Quaternary deposits (SGU) include mineralogical and grain size analyses. The results from SGU's investigation also include the total content of some elements and the HNO_3 soluble fraction of some additional trace elements.

The work was carried out in accordance with activity plan SKB AP PS 400-05-048. In Table 1-1 controlling documents for the performance of this activity are listed. Both activity plan and method descriptions are SKB's internal controlling documents. Data and results were delivered to the SKB site characterisation database SICADA with field note number

Table 1-1. Controlling documents for the performance of the activity.

Activity plan	Number	Version
Typprofilundersökningar vid platsundersökningen i Oskarshamn 2005	AP PS 400-05-048	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för berggrundskartering	SKB MD 132.001	1.0
Metodbeskrivning för jordartskartering	SKB MD 131.001	1.0
Metodbeskrivningar för jordborrningar och installation av grundvattenrör	SKB MD 630.003, SKB MD 600.006, SKB MD 600.004	1.0

1.1 Investigation area

The Oskarshamn area is located on the west Baltic Sea coastline in the south-east part of Sweden. The main land cover is forest on different soil types, together with partly open land on wet soils and bedrock outcrops. The landscape type has a lowland broken topography of small hills of till and exposed bedrock with small, mainly wet soil valleys in-between. There, the land types are forest, pasture and arable.

All known QD in the area were formed during or after the latest glaciation, the Weichselian. The surface distribution of QD (Figure 1-1) in the terrestrial part of the model area was mapped by /Rudmark et al. 2005, Rudmark 2004/. The Simpevarp area is completely situated below the highest coastline and was consequently covered by water after the last deglaciation. The highest altitudes constitute almost entirely of exposed bedrock. Till is the dominant QD and covers approximately half of the area. Fine-grained sediments and peat are mostly restricted to the long and narrow topographical lineaments which are characteristic for the investigated area.

Soils are formed during the interaction of the overburden, climate, hydrology and biota. In the investigated area the soil forming processes started as the land was lifted above the sea level. The soils of the Oskarshamn area are fairly young. In the Simpevarp area podsol and regosol dominate areas constituting of till or glaciofluvial material /Lundin et al. 2005a/. Umbrisol and gleysol dominate the fine-grained water laid sediments, which are used as arable land or meadows. Histosol is the most common soil type in the wetlands /Lundin et al. 2005b/.

The climate of the region is characterised by a snow covered winter period during three months in 60% of the years, ranging approximately from first of December to March, c 75 days. Greatest snow depth is on average 35 cm. The vegetation period extends over 195 days, mainly April to October. Hydrology is characterised by fairly dry summers, autumn rains with increasing runoff as well as with snowmelt periods during winter. Annual precipitation amounts to c 600 mm, having the highest monthly values in July–September with c 60 mm/month and the lowest in February–March with c 25 mm. Evapotranspiration reaches over 400 mm resulting in a runoff of less than 200 mm. The mean annual temperature is c +6.5°C /Raab and Vedin 1995/.

2 Objective and scope

The Laxemar subarea is characterised by a relatively flat bedrock surface with numerous topographic lineaments. The highest topographical areas are dominated by till and outcrops. The valleys are generally covered by relatively thick layers of till and water laid deposits. Parts of the valleys may act as discharge areas for ground water from a deep repository. It is therefore of importance to characterise the Quaternary deposits (QD) and soils in these topographical lineaments. Results from the mapping of Quaternary deposits show a glaciofluvial deposit, which can be followed from Lilla Laxemar towards the north-west. This deposit may be of hydrological significance for groundwater transport in the Laxemar subarea.

Refraction seismic data across the topographic lineaments show presence of low velocity zones in the bedrock, which imply presence of fracture zones along the topographical lineaments /Lindqvist 2004, 2005/. The properties and distribution of these zones are of high importance for the underground construction of the deep repository for high radioactive waste.

The aims of the present project are:

1) To describe the properties of bedrock and possible fracture zones underlying the overburden in the topographical lineaments.

2) To describe the stratigraphical distribution of QD in the topographical lineaments.

3) To define the properties of soils, which are needed for hydrological and transport models.

4) To determine the properties and total depth an of the glaciofluvial deposit.

5) To define soil properties and composition of the vegetation in the valleys.

6) To gain data which can be used for reconstruction of the Quaternary development of the area.

7) To install soil tubes for groundwater sampling and monitoring. The monitoring wells must enable both groundwater level measurements and characterisation of the hydraulic properties of the soil deposits by slug tests.

The investigation includes soil classification and stratigraphical studies of QD in machine-cut trenches at four sites. Samples from soil/rock drillings were studied at these four and at two additional sites. The bedrock surface was reached in three of the machine cut trenches. The glaciofluvial deposit was only studied by means of soil/rock drillings.

3 Equipment

3.1 Description of equipment/interpretation tools

A crawler-excavator (Figure 3-1) carried out the excavations of the Quaternary cover. The excavator is capable of cutting trencher down to a depth of c 5 m below the ground surface.

The lowermost parts of the trenches were situated below the groundwater table and a pump was therefore used to drain the trenches.

Most of the investigated points were determined with DGPS but some points were determined with GPS.

The sampling of bedrock exposures was performed by the use of a sledgehammer. A digital camera was used and photos were taken of rock exposures.

Spade and scraper were used during the documentation and sampling of Quaternary deposits.

Altogether 20 samples were analysed for grain size composition and $CaCO_3$ content at SWECO, Geolab in Stockholm. Three samples were analysed for organic material at the same laboratory.

Figure 3-1. *The crawler-excavator when cutting a trench at Profile 5 east of Mederhult.*

The total and HNO_3 soluble fraction of the Quaternary deposits were determined with ICP at Analytica AB in Luleå.

Four clay and three till samples were analysed for clay mineralogy. The till samples were also analysed for primary minerals. These mineralogical analyses were performed at the Geological Survey of Sweden by the use of X-ray diffraction.

The drillings and samplings of soil were performed with a track-driven drilling rig, GM 65 GTT. The soil samplings were performed by auger drilling (Ø = 82 mm) and the soil/rock drilling was performed with air-rotary drilling with a casing driver system (NOEK).

4 Execution

4.1 General

Based on the refraction seismic information /Lindqvist 2004, 2005/, excavations and soil/rock drillings were performed at four sites and soil/rock drillings at two additional sites (Figure 1-1, Figure 1-2, Figure 1-3, Figure 1-4, Figure 1-5 and Figure 1-6). The bedrock surface was reached and documented in three of the trenches.

The documentation of the bedrock exposures was carried out in accordance with the method description for bedrock mapping (SKB MD 132.001, SKB internal document).

The Quaternary deposits were documented according to SKB MD 131.001 (internal document).

The-drilling and sampling in soil included the following: preparation and mobilisation, drilling and sampling in soil, installation of groundwater monitoring wells, finishing of work, surveying of boreholes, environmental control programme and data handling (SKB MD 630.003, SKB MD 600.006, SKB MD 600.004, internal documents).

The methods used during the classifications of soils were mainly based on the instructions to the Swedish Forest Soil Inventory /RIS 2005/.

4.2 Execution of field work

The positions of the investigated localities are shown in Table 4-1, Table 4-2, Figure 1-1, Figure 1-2, Figure 1-3, Figure 1-4, Figure 1-5 and Figure 1-6.

The bedrock surface was reached in trench 1, 3 and 4. The excavated outcrops were thoroughly cleaned, documented and sampled. Documentation included: rock type, colour, texture, ductile structures, magnetic susceptibility, alteration and fractures, fracture frequency and fracture fillings.

Shovels and scrapers were used to clean the walls of the trenches and to collect soil samples. Studies were made of the stratigraphies including sedimentary and deformational structures, lithology, sorting, etc. At Profiles 1, 3 and 4 the Quaternary deposits were described in several sections.

Fabric analyses were performed on 32 grains, in glacial till, at Profile 1 according to /Dowdeswell and Sharp 1986/. A horizontal surface was first prepared 1.5 metre below ground surface. Gravel and larger particles were measured. The relationship between the *a* and *b* axis was always larger than 3/2. The direction and dip of the *a* axis was measured on 32 particles.

Most soil determinations follow the instructions for the Swedish National Inventory of Forests /RIS 2005/. Vegetation and root inventories were made for all trenches. Sampling for soil physical and chemical analyses was carried out in three profiles in trenches 1, 3 and 4 and in one profile in trench 5. Dependent on regolith thickness sampling was made to 3.0 m in trench 1, 3.5 m in trench 3, 2.5 m in trench 4 and 3.0 m in trench 5.

Table 4-1. Position of the investigated sites. Investigations in machine-cut trenches were carried out at Profiles 1, 3, 4 and 5. The altitude above the present sea level (m.a.s.l.) has not been determined at all the investigated sites.

Profile nr	Id-code	East	North	m.a.s.l.	Bedrock sample	Soil	QD
1	PSM007160	6 367 191.33	1 547 463.00	12.96		X	X
1	PSM007161	6 367 184.60	1 547 465.27	13.11			X
1	PSM007162	6 367 185.79	1 547 449.25	13.46		X	X
1	PSM007163	6 367 191.79	1 547 448.65	13.22			X
1	PSM007164	6 367 188.44	1 547 437.77	13.93		X	X
1	PSM007165	6 367 189	1 547 458	–	X		
1	PSM007166	6 367 188	1 547 453	–	X		X
1	PSM007167	6 367 192	1 547 442	–	X		
3	PSM007170	6 367 678.02	1 549 786.68	7.32			X
3	PSM007171	6 367 689.44	1 549 787.95	6.57		X	X
3	PSM007172	6 367 675	1 549 784	–	X		
3	PSM007173	6 367 693.45	1 549 771.49	6.17	X	X	X
3	PSM007174	6 367 682.53	1 549 776.01	6.32		X	
4	PSM007180	6 366 535.94	1 548 726.98	12.34		X	X
4	PSM007181	6 366 542.04	1 548 718.79	12.31		X	
4	PSM007182	6 366 540.12	1 548 722.05	12.31			X
4	PSM007183	6 366 528.50	1 548 728.53	12.30		X	
4	PSM007185	6 366 539	1 548 719	–	X		
4	PSM007186	6 366 538	1 548 719	–	X		
4	PSM007187	6 366 536	1 548 719	–	X		X
4	PSM007188	6 366 533	1 548 719	–	X		
5	PSM007190	6 367 982.31	1 547 714.26	8.13			X

Table 4-2. Coordinates and type for all boreholes.

Profile nr	Borehole	North	East	Elevation	Type
1	SSM000222	6367190.616	1547490.981	12.785	Soil/rock drilling, soil sampling, groundwater monitoring well
1	SSM000223	6367171.742	1547513.653	13.693	Soil/rock drilling, soil sampling, groundwater monitoring well
1	PSM007200	6367175.029	1547500.388	12.747	Soil/rock drilling
1	PSM007201	6367171.141	1547523.551	13.274	Soil/rock drilling
1	PSM007202	6367170.367	1547536.465	13.574	Soil/rock drilling
2	SSM000224	6368091.688	1548666.979	6.904	Soil/rock drilling, soil sampling, groundwater monitoring well
2	SSM000225	6368092.167	1548669.442	6.937	Soil/rock drilling, soil sampling, groundwater monitoring well
2	PSM007148	6368096.789	1548661.316	6.425	Soil sampling
2	PSM007149	6368103.250	1548625.099	6.037	Soil sampling
2	PSM007150	6368107.436	1548571.309	5.518	Soil sampling
2	PSM007151	6368108.775	1548524.107	5.608	Soil sampling
2	PSM007152	6368105.942	1548595.665	5.443	Soil sampling
2	PSM007153	6368105.333	1548607.241	5.690	Soil sampling
2	PSM007203	6368102.226	1548660.283	6.362	Soil/rock drilling

Profile nr	Borehole	North	East	Elevation	Type
2	PSM007204	6368085.694	1548665.773	6.578	Soil/rock drilling
2	PSM007205	6368070.736	1548672.853	6.750	Soil/rock drilling
2	PSM007206	6368114.143	1548655.468	6.160	Soil/rock drilling
2	PSM007207	6368125.078	1548646.659	5.992	Soil/rock drilling
2	PSM007208	6368058.601	1548675.409	7.114	Soil/rock drilling
2	PSM007209	6368047.288	1548678.187	7.358	Soil/rock drilling
2	PSM007210	6368035.577	1548681.049	7.796	Soil/rock drilling
2	PSM007211	6368014.043	1548685.541	8.710	Soil/rock drilling
2	PSM007212	6368095.376	1548667.204	6.601	Soil/rock drilling
3	PSM007213	6367730.737	1549800.977	6.610	Soil/rock drilling
3	PSM007214	6367729.077	1549803.155	6.661	Soil/rock drilling
3	PSM007215	6367724.545	1549808.199	7.304	Soil/rock drilling
3	PSM007216	6367723.394	1549811.972	8.140	Soil/rock drilling
3	PSM007217	6367720.799	1549817.938	10.018	Soil/rock drilling
3	SSM000226	6367696.292	1549790.186	6.972	Soil/rock drilling, soil sampling, groundwater monitoring well
3	SSM000227	6367693.239	1549787.713	7.279	Soil sampling, groundwater monitoring well
Lilla Laxemar	SSM000230	6366219.918	1550069.106	5.101	Soil/rock drilling, soil sampling, groundwater monitoring well
4	SSM000228	6366503.701	1548718.363	13.087	Soil/rock drilling, soil sampling, groundwater monitoring well
4	SSM000229	6366475.650	1548721.342	13.677	Soil/rock drilling, soil sampling, groundwater monitoring well
4	PSM007218	6366495.027	1548719.083	12.097	Soil/rock drilling
4	PSM007219	6366485.380	1548720.978	12.272	Soil/rock drilling

4.3 Data handling/post processing

The excavated rock exposures were documented and sampled. The information was transferred into an Access database by using the database application BGDATA, version 1.7.3. The Access database and a selection of data are stored in SKB's SICADA database.

The stratigraphical information from studies of Quaternary deposits was stored in SGU's database "Jorddagboken", version 5.4.3. Data from this database were exported to Excel files, which were delivered to SKB. Samples for analyses of grain size distribution, mineralogy and chemical compositions were taken from all types of Quaternary deposits.

All data from the studies of soils and QD have been incorporated in SKB's database SICADA.

4.4 Site survey methods

At each of the trenches a site description was made including type of field and bottom layer vegetation, hydrology, frequency of stones and boulders, thickness of the humus layer, root depth and soil type distributions. The vegetation inventory was made before excavations and extended over a longer and wider area as compared with the actual excavations. This means inclusion of other vegetation types as compared to the actual area for the trenches.

4.4.1 Vegetation

Vegetation types and dominating species within the list of species used in the "The Swedish National Inventory of Forests" /RIS 2005/ and percentage of coverage were determined.

Vegetation types included in the bottom layer:
1 lichen type
2 lichen-moss type
3 lichen rich type
4 *sphagnum* type
5 wet moss type
6 mesic moss type

Field layer:
01 tall herbs without shrubs
02 tall herbs with shrubs/bilberry
03 tall herb type with shrubs/vitis idea
04 low herbs without shrubs
05 low herbs with shrubs/bilberry
06 low herbs with shrubs/vitis idea
07 without field layer
08 broad leafed grass
09 narrow leafed grass
10 tall sedge
11 low sedge
12 horse tail type
13 bilberry type
14 vitis idea/whortleberry, marsh rosemary type
15 crowberry/heather type
16 poor shrubs type

4.4.2 Site hydrology – Soil moisture class

This variable reflects the average distance from the ground surface to the groundwater table during the vegetation period. Estimations are made from geophysiographical conditions, i.e. local topography and hydrological features, etc.

1 dry
2 fresh
3 fresh/moist
4 moist
5 wet

4.4.3 Stoniness – Stones and boulders

Statement was posed on possibility to perform the stoniness inventory /Viro 1958/. The special determination means pushing a 10 mm steel rod into the soil until a stone or boulder is hit within maximum depth of 30 cm. This was made on each 2 m distance in a central line along the trench and in two points one metre on both sides at each 2 m distance of the central transect. The average stoniness depth is used in a function to estimate the volumetric content of stones and boulders in the soil. The values were compared with actual measurements on the trench wall. However, this wall was not in the centre of the trench but on one of the trench sides.

0 measurements not possible to make
1 measurement made

The equation used in the calculations was: $Y = 65.7–2.22 X$
Y: stoniness in vol. %
X: rod penetration depth

4.4.4 Root depth

The root extension depth was determined with the mineral soil surface as the upper boundary. Depths were measured for fine and coarse roots, separated on the two classes at a diameter of one cm.

4.4.5 Soil type

Classification on soil types refers to the international World References Base system (WRB) /WRB 1998/. The system used is a simplified version including the appropriate types for Sweden and with field determinations, which actually is not totally correct while a thorough classification needs chemical analysis. However, the simplified determination would reflect an almost correct classification.

1 Histosol
2 Leptosol
3 Gleysol
4 Podzol
5 Umbrisol
6 Cambisol
7 Arenosol
8 Regosol
9 Unclassified (could be caused by too much water, etc)

4.5 Drilling and sampling in soil

4.5.1 Mobilisation and preparation

Before drilling commenced, service and function control of all equipment was conducted. It was checked that type of fuel, oil and grease was in accordance with SKB's instruction for chemical products used for drill works, SKB MD 600.006. Finally, the equipment was cleaned according to SKB's instruction, SKB MD 600.004.

Mobilisation onto the site included transport, cleaning of all in-hole equipment, preparation of the site, lining up the machine and final control of function. It also included transport of pipes, sand, bentonite, and sampling pots for soil as well as all other necessary equipment.

4.5.2 Drilling and sampling in soil

The soil samplings were performed by auger drilling (Ø = 82 mm).

When the soil sampling was finished, air-rotary drilling with a casing driver system (NOEK) was performed in the same borehole. To ensure that the bedrock was reached, the drilling continued approximately 1–3 metres into the bedrock. The soil sampling was performed within the activity according to AP PS 400-05-048 and the results are presented separately. The client received the soil samplings.

The soil samplings were marked with borehole ID (e.g. SSM000226:1) and the soil samplings for environmental studies were marked as above but with the additional "M" (e.g. SSM000222:1M).

The characterisation of the soil was done in the field.

4.5.3 Installation of groundwater monitoring wells

Groundwater monitoring wells were installed inside the drill casing. PEH screens (Ø: 63/50 mm, length: 1–2 m, slot: 0.3 mm) and PEH casings (Ø: 63/50 mm) were used. Filter sand (0.4–0.8 mm) and bentonite clay (Volclay SG40) were filled outside the well while the drill casing was pulled out. A PEH cap was installed at the top to prevent debris entering the casing.

One groundwater monitoring well (SSM000227) were installed directly in the auger drilling hole.

After installation, function tests were performed. Water was either pumped out or blown out by air.

4.5.4 Completion of work

The rig was removed and the site was cleaned.

After finishing the work, all investigation points were temporarily surveyed by precision GPS, x-, and y-coordinates. The accuracy of the coordinates is ± 10 metres. After completion SKB executed a precision survey and the actual coordinates were documented in the Sicada database.

4.5.5 Environmental programme

Checklists according to SKB's routine for the environmental program were signed by the Activity Leader and were filed in SKB's archive.

4.5.6 Data handling

Records for the following items: Activities, cleaning of equipment, installation of groundwater monitoring wells and pore pressure devices, and discrepancy reports have been collected by the Activity Leader for quality control and storage.

4.6 Analyses and interpretations

4.6.1 Physical properties of Quaternary deposits

The samples analysed for chemical and physical properties are summarised in Table 4-3.

Grain size analyses, on material < 20 mm, were carried out on 20 samples according to SS027123 and SS027124 /SIS 1992ab/. The grain size distribution of coarse material (20–0.063 mm) was determined by sieving and finer material with hydrometer. The content of $CaCO_3$ was determined on the same 20 samples (grain sizes < 63µ) using Passons apparatus /Almén and Talme 1975/. At the same laboratory three samples were analysed for organic material by loss of ignition.

The fabric measurements were plotted in a circle diagram (Figure 5-15). Three-dimensional vector analysis was used to extract the eigenvectors (V1, V2 and V3) and normalised eigenvalues (S1, S2 and S3) in the diagrams presented in Figure 5-15. Eigenvector V1 refers to the direction of maximum clustering, and V3 to that of minimum clustering. The eigenvector V1 are regarded as significant when the S3-values are lower than 0.227. Values within brackets, i.e. statistical proposed directions of vector V1, are reconsidered to transport-directions shown without brackets.

The eigenvalues summarise fabric strength or degree of clustering. S1 measures the strength of clustering about the mean axis V1. S1-values > 0.7 is regarded as strong orientation, values < 0.5 is regarded as random orientation.

Table 4-3. The QD samples used for analyses of physical and chemical properties.

Profile	Id-code	D b s (m)	Grain size and CaCO3	XRD <2 ɥm	XRD Grains <2 mm	Chemical composition	Quaternary deposit
1	PSM007160	0.7–0.8	X	X		X	Gyttja clay
1	PSM007160	1.0–1.1	X			X	Sand/gravel
1	PSM007160	1.25–1.3	X	X		X	Glacial clay
1	PSM007160	2.2	X			X	Gravelly till
1	PSM007162	1.0–1.2	X	X	X	X	Sandy till
2	SSM00224	12.0–13.0	X			X	Sand/gravel
2	SSM00225	2.0–2.8	X			X	Sand
3	PSM007170	1.2	X			X	Clay
3	PSM007171	0.5	X	X		X	Gyttja clay
3	PSM007171	1.25	X			X	Sand/gravel
3	PSM007171	1.4	X			X	Glacial clay
3	PSM007171	1.8	X	X		X	Glacial clay
3	PSM007171	3.2	X	X	X	X	Gravelly till
3	PSM007173	1.5	X			X	Sandy till
4	PSM007180	0.3	X			X	Sand
4	PSM007180	1.4	X			X	Glacial clay
4	PSM007180	2.3	X			X	Silt layer in the till
4	PSM007180	2.5	X	X	X	X	Sandy till
5	PSM007190	1.1–1.3	X			X	Gyttja

The strength parameter C, ln(S1/S3), expresses the "strength" of the preferred orientation in the data sample. A high C-value indicates that the clustering/girdling is strong. A value over 1.9 denotes a confidence level of 90% if N is 50 or more /Woodcock and Naylor 1983/.

The shape parameter K, lnS1/S2)/ln(S2/S3), expresses the gradient of a line joining the graph origin to the point representing the sample. K ranges from zero (uniaxial girdles) to infinite (uniaxial clusters). High K-values indicate a clustered distribution (see Figure 5-15).

4.6.2 Chemical and mineralogical analyses of Quaternary deposits

Four clay and three till samples were analysed in order to characterise their mineral contents. In the tills, minerals in the matrix fraction (grain size fraction < 2 mm) were determined qualitatively and quantitatively. Clay minerals of the clay fraction were determined separately in addition. In the clays only minerals of the clay fraction (fraction < 2 µm) were determined. The analyses were performed at the Geological Survey of Sweden by the use of X-ray diffraction.

The till samples were split to 30–35 g portions. One portion was used for analyses of the whole matrix and the other portion for separation of the clay fraction. The matrix portion was crushed to grain size < 0.5 mm and then split to 1.7–1.8 g. An internal standard, zincite (ZnO) 10% by weight, was added to sample. Sample + zincite was ground for 10 minutes in alcohol. The powder obtained was prepared for analysis by sideward packing to obtain random orientation of crystallites. For separation of the clay fraction 30–35 g of the till was suspended in distilled water in beakers and treated in ultra sonic for about half an hour. The suspension was stirred and set for sedimentation. After a set time the upper part of the suspension containing clay particles was siphoned from the suspensions and filtered for oriented specimens preparation /Drever 1973/.

From the clay samples 13–14 g and 22 g (for one of them) moist material was collected by a spoon. The samples were transferred to 500 ml cylinders and disintegrated in distilled water. The suspended particles of the clays were set for sedimentation over night. The clay fraction (< 2 µm) particles were siphoned from upper part of the suspension the next day. Then the suspension was stirred and set for new sedimentation to the next day. That day clay particles were siphoned from the suspension again. This was repeated until the distilled water was suggested free from particles in the upper part of the cylinders (clear water). The clay particles < 2 µm in the large volumes of suspensions were centrifuged down in an ultracentrifuge. Then the concentrated suspensions were freeze-dried. For quantitative mineral analysis of the < 2 µm fractions 10%, by weight, zincite was added to 1.8 g of the frees dried material. For qualitative clay mineral analysis 0.15 g from the freeze-dried fraction was suspended in distilled water and disintegrated by ultrasonic treatment. These suspensions were filtered for oriented specimens preparation /Drever 1973/ in the same way as the clay fraction from the tills.

The X-ray diffraction analyses were carried out at SGU in Uppsala using a Siemens D5000 (theta-theta) diffractometer (CuKα). The X-ray generator was operated at 50kV and 40 mA for the quantitative mineral determinations. The clay mineral analyses generator was operated at lower voltage, 40 kV and 40 mA, respectively. Scans were run from 5° to 65° (2-Theta) counting 2 s per 0.02° and from 59° to 64° with counting 5 s per 0.01° (2-Theta) cf /Środoń et al. 2001/ for the quantitative mineral determinations. These analyses were performed a 2.0 divergence slit, a 0.6 mm antiscatter slit and 0.1 mm receiving slit in the ray path. When the clay mineral was analysed, scans were run from 2° to 35° (2-Theta) with a 1° divergence slit, a 2 mm antiscatter slit and 0.1 mm receiving slit in the ray path.

The X-ray diffration raw files were taken up in the Bruker/Siemens software DIFFRAC^{PLUS} (version 2.2), including the /PDF 1994/ database for mineral identification. The best-fit lines for the identified minerals are shown with different colours in the X-ray diffractograms shown for the randomly analysed specimen.

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 applied for identification of the clay minerals.

The quantitative X-ray diffraction analyses were carried out in two ways, first according to the method described /Środoń et al. 2001/, somewhat modified, using MIF values determined on minerals from own collection and second by means of Rietveld techniques in TOPAS R software /Bruker AXS 2003/.

For analyses of As, Cd, Cu, Co, Hg, Ni, Pb, B, Sb, Se and S the samples were first dried at 50°C. The samples were thereafter digested in HNO_3 and analysed with ICP-MS. The total contents of the other elements were analysed. The samples were fused in a carbon crucible with a flux (lithium metaborate) at 1,000°C. The "bead" which formed was dissolved in HNO_3 and the metal concentrations were determined with ICP-MS. All results are shown as content/dry weight (105°C).

4.6.3 Analysis of soil physical properties

Volumetric mineral soil samples were taken to determine dry bulk density, porosity, water retention and hydraulic conductivity. One profile (in trench 3 2 profiles) was sampled, if possible, at the depths: 5–10, 20–25, 50–55, 80–85, 120–125, 170–175 and 250–255 cm (in trench 5 also 295–300 cm). Sampling was made using steel cylinders. The sizes of these were a height of 5 cm and a radius of 3.6 cm. Two replicates were taken in each layer.

Analysis of retention was made using porous suction beds and of hydraulic conductivity in permeameters with constant head. 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. Time for measurements varied mainly between 1 and 60 minutes but extended up to 14 hours for one sample.

4.6.4 Soil sampling for and analysis of soil chemical properties

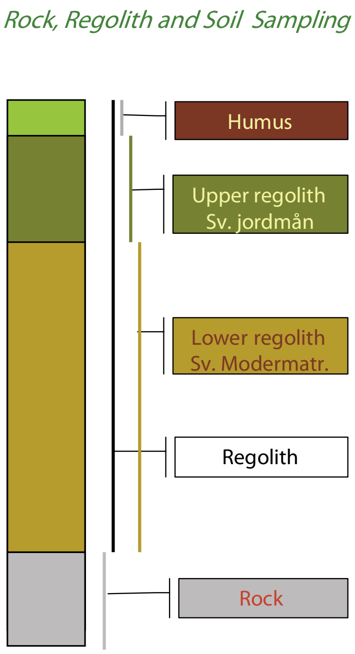
Soil was sampled from the profiles and the system was adopted both to international conditions and the traditional Swedish system to give the possibility to compare with the ongoing Swedish "Forest Soil Inventory".

The humus layer was sampled separately and mineral soils mainly in relevant layers down to regolith depth (Figure 4-1).

Mineral soil layers: 0–10 (H10 sample under mull and mull like moder), 10–20 and 55–65 cm.

In potential Podzols the layer 0–5 in the B-horizon was added to provide possibilities for chemical characterisation. Deeper layers were sampled at fixed depths, i.e. 1.0 m, 1.5 m, 2.0 m, 2.5 m 3.0 m and 3.5 m if sufficient soil depth.

Chemical analysis included pH, C, N, exchangeable Ca, Mg and K in 1 M NH_4Ac at pH 7, titratable acidity, extractable K and P in ammonia-acetate (AL) and 2M hydrochloric acid (HCl). Further, also *Aqua Regia* extractions were made with determinations of Fe, Al, Mn, Na, K, Ca, Mg and Zn. C, N and pH were analysed in three profiles of trenches 1, 3 and 4 and one in trench 5. The other analyses were carried out for one profile in each trench.



Sampling depths, cm

Main types	Podzols	Peat
0-30	0-30	0-30
0-10	0-10	30-50
10-20	10-20	
	B 0-5	
55-65	55-65	

***Figure 4-1.** The regolith over the bedrock with soil sampling depths in three categories of soils.*

4.7 Nonconformities

The stratigraphy in trench 5 was not properly described due to the low slope stability of the gyttja sediments present at that site. Low slope stability also caused sliding in the trench at Profile 3. That did, however, not omit the characterisation of the Quaternary deposits and soils at that site.

5 Results

5.1 Bedrock

5.1.1 Introduction

The three trenches where the bedrock was exposed are all situated within the part of the Laxemar subarea that is dominated by so called Ävrö granite, see Figure 5-1. Ävrö granite is a collective name for a suite of more or less porphyritic rocks that vary in composition from quartz monzodiorite to granite, including quartz diorite, tonalite, granodiorite and quartz monzodioritic varieties.

Profile 1, is east-west trending and situated in the western part of the Laxemar subarea, close to the inferred lineament, ZSMNS059A (nomenclature of Model Laxemar 1.2 /SKB 2006/), see Figure 5-1. Trenching across the lineament was not possible since the overburden is too thick (more than 10 metres). The exposed bedrock was documented and sampled at three observation points. The bedrock is described under Section 5.1.2 below.

The outcrops west and north west of Profile 1, were previously documented during the bedrock mapping of the Laxemar subarea /Nilsson et al. 2004/ and show locally high frequency of micro fractures sealed with epidote and quartz. Locally the bedrock is also altered and red staining/oxidation of rock groundmass occur frequently in the area.

Profile 3 is situated in the north eastern part of the Laxemar subarea and is trending south-east–north west across lineament ZSMNE040A, see Figure 5-1. Geologically the excavation is located in the Ävrö granite close to a complex area to the north-west, consisting of equigranular quartz monzodiorite, minor bodies of fine- to medium grained granite and gabbro. The exposed bedrock surface was documented in two observation points and is described under Section 5.1.2 below.

Profile 4 is situated in the south central part of the Laxemar subarea and is trending north south, close to the inferred lineament ZSMEW007A, see Figure 5-1. The bedrock was continuously exposed over a 12 metre section and revealed a strongly fractured and altered bedrock. The bedrock was documented in four observation points and is described in next section.

The outcrops north and south of the excavation were documented during the bedrock mapping of the Laxemar subarea /Nilsson et al. 2004/ and consists of relatively quartz rich Ävrö granite with weak or no signs of alteration.

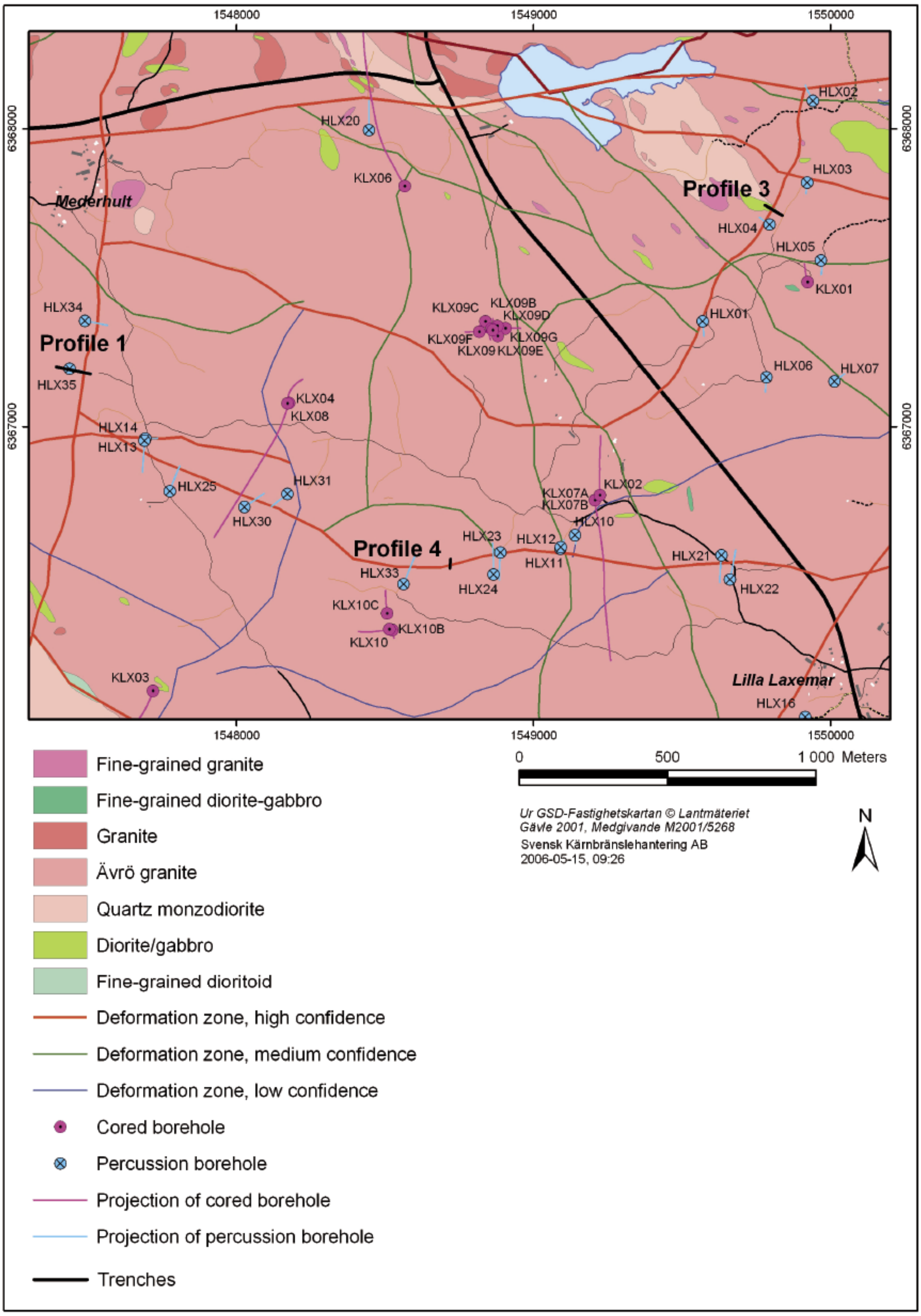


Figure 5-1. *Bedrock map over the Laxemar-area. Black lines show the three sites where the bedrock was investigated.*

5.1.2 Documentation of rock exposures

Profile 1 – excavation

The bedrock in Profile 1 was exposed in three separate parts with water filled depressions in-between, see Figure 5-2.

The exposed bedrock was documented and sampled at three sites, from east to west (PSM007165–PSM007167). The bedrock is dominated by medium grained, equigranular to weakly porphyritic, granodioritic Ävrö granite. Minor enclaves of fine-grained mafic rock occur subordinately. The Ävrö granite is generally grey-reddish to reddish. The reddish colour is most likely indicating a secondary oxidation/alteration of the entire rock mass.

The fracture frequency is generally low in the eastern part, with only 1–2 fractures longer than 0.5 m per metre exposed rock surface. In the central, and western part the fracture frequency is slightly higher. Fractures, sealed with epidote, chlorite and quartz are also frequent in this part. Slickenlines along chlorite coated fracture surfaces indicate that movements have occurred along these fractures, see Figure 5-3.

In the western part of the excavation, on the eastern side of the westernmost rock exposure, minor open fractures, filled with laminated clay/silt were exposed (Figure 5-14). This phenomenon is further explained in Section 5.2.1 below.

The magnetic susceptibility of Ävrö granite is relatively low along the entire exposed section and varies between 28 and 270×10^{-5} SI units. The lowest values were obtained in the central and western part in connection to red staining and high frequency of micro fractures. The normal values for comparable unaltered Ävrö granite is approximately $500–2{,}000 \times 10^{-5}$ SI units.

The presence of chlorite-, epidote- and quartz-sealed fractures, red staining and a relatively low magnetic susceptibility are all indicators of brittle deformation, which indicate that the trench is situated in the vicinity of a fracture zone.

Profile 3 – excavation

Figure 5-2. *Profile 1, situated in the western part of subarea Laxemar. Picture is looking to the west. Observation points are marked with id-number in picture.*

Figure 5-3. *Chlorite coated fracture surface with slickenlines indicating movements along the fracture planes.*

The bedrock in the excavation at Profile 3 was exposed in two separate parts. The south-eastern part is the continuation of an outcrop that was documented during the bedrock mapping of the area 2004 /Nilsson et al. 2004/. The north-western part of the excavation reveals also a continuation of an outcrop. The bedrock in the central part of the excavation was not reached due to thickness of overburden. The south-eastern and north-western parts were documented separately in the two observation points, PSM007172 and PSM007173, se Figure 5-4.

The south-eastern exposure (PSM007172) is dominated by medium grained, Ävrö granite with scattered potassium feldspar megacrysts. The composition appears to vary from granodioritic in the south-eastern part to quartz monzodioritic in the central and north-western part of the excavation. The rock is massif to weakly foliated.

The fracture frequency is low, with less than 1 fracture/metre. A few minor, millimetre to centimetre thick epidote and chlorite sealed fractures is noted.

The magnetic susceptibility of the Ävrö granite varies from approximately 600×10^{-5} SI units in the upper granodioritic part and approximately $1{,}100 \times 10^{-5}$ SI units in the central and more quartz monzodioritic part.

In the north-western exposure (PSM007173), a strongly fractured and complex rock mixture of altered and red stained, quartz monzodioritic Ävrö granite, fine grained, red granite and a fine grained mafic rock is exposed, see Figure 5-5. Veins of milky quartz and feldspar occur also frequent as well as centimetre thick fractures sealed with epidote.

The magnetic susceptibility varies from approximately 1,000–1 500×10^{-5} SI units in the north-western part of the most well preserved quartz monzidioritic Ävrö granite to approximately $10–50 \times 10^{-5}$ SI units in the complex, fractured rock mixture towards the central part of the excavation.

The decrease in magnetic susceptibility, increase in fracture frequency, red staining and presence of epidote and quartz sealed fractures, towards the central part of the topographical lineament, imply vicinity to a fracture zone.

Figure 5-4. *Profile 3. Looking to north-west. Observation points are marked with id-number in picture.*

Figure 5-5. *North-western part of the trench at Profile 3. A fractured, complex rock mixture of strongly altered and red stained, quartz monzodioritic Ävrö granite, fine grained red granite and fine grained mafic rock.*

Profile 4 – excavation

The trench at Profile 4 constituted a 12 m long, continuos rock exposure in north-south direction. The excavation cut a north-west – south-east trending fracture zone. Due to the strong alteration of the rock, a part of the altered rock mass was excavated away by the crawler-excavator. However, this revealed an easily studied vertical cut through the fracture zone. The bedrock is sampled and documented in four observation points, PSM007185–PSM007188, see Figure 5-6.

The bedrock in the northern part of the excavation (PSM007185) consists of a fractured, red stained and oxidised granitic Ävrö granite. Most of the fractures are sealed with chlorite and calcite. Epidote occurs also relatively frequent, se Figure 5-7.

The alteration increase towards the central part of the excavation and 2 m south of PSM007185 the Ävrö granite is strongly altered and fracture. A great part of the rock is strongly chloritised and greenish in colour. Millimetre wide fractures sealed with calcite are also present.

In the central part of the zone (the core-zone), approximately 2 m further to the south, the rock alteration is most intense and the entire rock is argillic altered to a green and red/brown gouge, alternating in centimetre to decimetre thick layers, see Figure 5-8.

The gouge (the core zone) is approximately 0.6 m thick, measured perpendicular to strike of the zone and layering. The strike of the zone is estimated to approximately 310°/42°. The alteration appears to follow fracture planes in the same direction.

The argillic alteration decreases successively towards south. At observation point PSM007188, approximately 2 m south of the core zone, the grade of alteration and fracture frequency are comparable to what was noted in the northern part of the excavation, i.e. a medium grained, red stained/oxidised granite with relatively high frequency chlorite sealed fractures.

The bedrock alteration variations along the excavated profile 4 are schematically presented in Figure 5-9.

Figure 5-6. *The trench at Profile 4. Looking to north-west. Observation points are marked with id-number in the picture.*

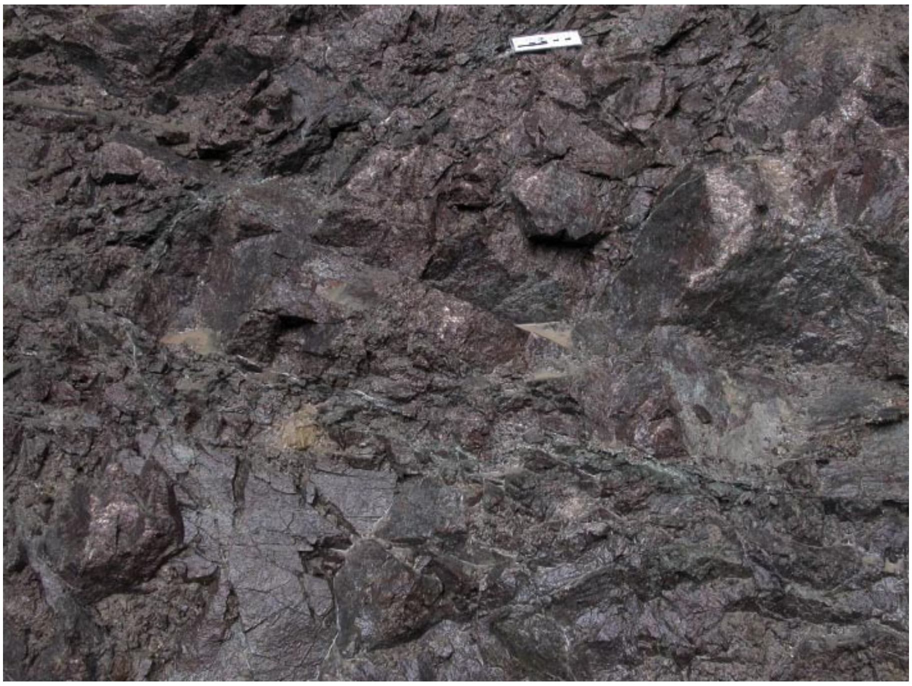
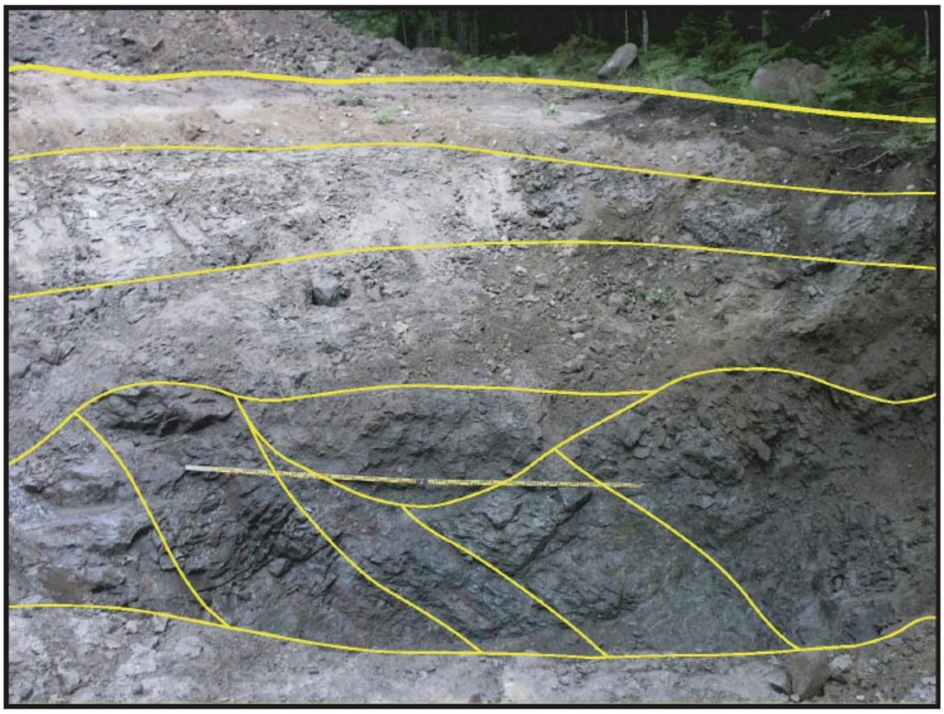


Figure 5-7. *Strongly altered, fractured and red stained/oxidised Ävrö granite in the northern part of the excavation at Profile 4.*

Figure 5-8. *The central part (the core zone) and most intensely altered part of the zone at Profile 4. (The hammer-handle is 0.6 m.)*



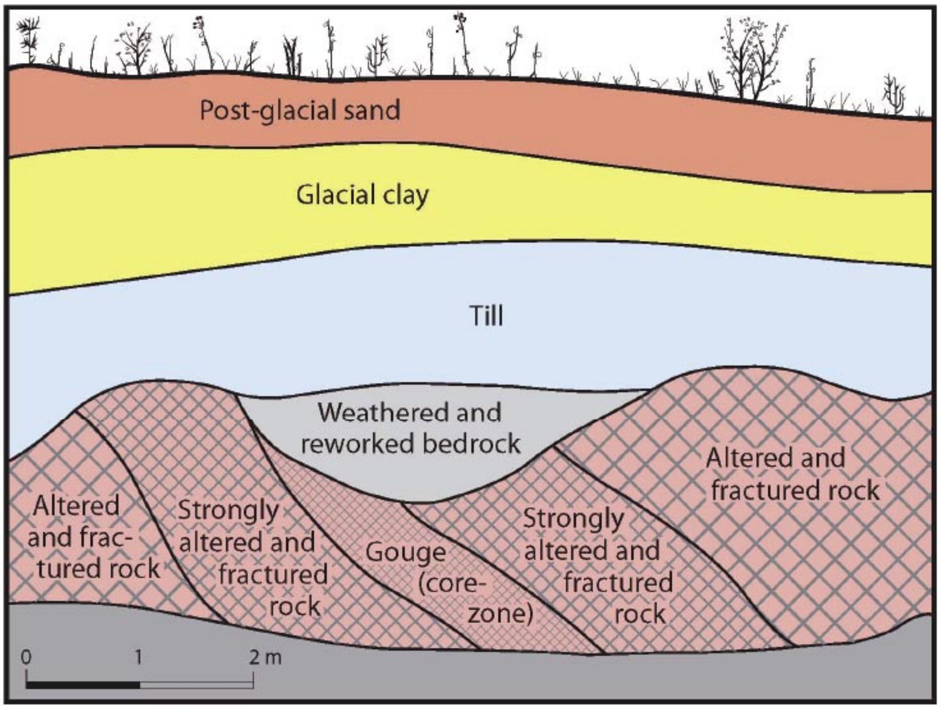


Figure 5-9. *Photograph and schematic illustration of the bedrock alterations, which were observed during the documentation of the excavation at Profile 4. The photo was taken towards north-west. The stratigraphical distribution of the Quaternary deposits overlying the bedrock is also shown in the schematic illustration.*

The magnetic susceptibility along the investigated section is constantly low and varies in between 20–150×10^{-5} SI units. The lowest values are received in the central part, in connection to the most intensely altered rock (the core-zone).

Fractures longer than 1 m was measured in the four observation points in excavation Profile 4. The result is presented in stereographic projections in Figure 5-10 and Figure 5-11. The result suggests that the dominant fracture orientation is north-west–south-east Figure 5-10. The fracture planes are generally gently dipping towards north-east (Figure 5-11). Fracture sets are also noted in north-east, dipping towards north-west.

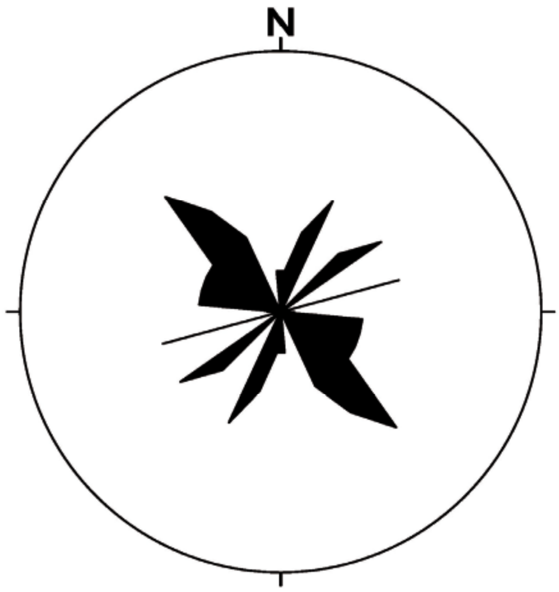


Figure 5-10. *Orientation of fractures in the excavation at Profile 4 illustrated in a rose diagram.*

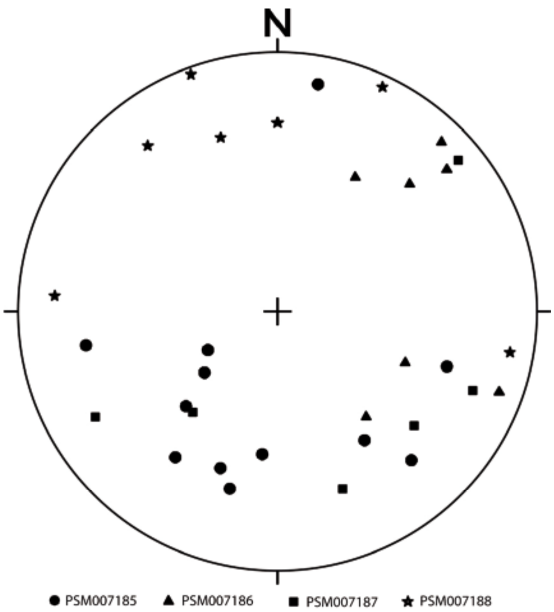


Figure 5-11. *Poles to planes of fractures in the excavation at Profile 4, on the lower hemisphere of a Schmidt stereographic plot.*

5.2 Results from field observations of Quaternary deposits and soils – Introduction

All the investigated sites except SSM000230 are situated in narrow topographical lineaments (Figure 1-1, Figure 5-12). According to the map of Quaternary deposits Profile 5 is covered by peat and Profiles 1, 3, and 4 by water laid sediments (sand and clay cf /Rudmark et al. 2005/). The valleys are surrounded by areas dominated by till and exposed bedrock, which mainly are covered by forest. Both SSM000230 and Profile 2 are located to at a small glaciofluvial deposit, which have a north-westerly direction (Figure 1-1). All sites are situated below the highest coastline and the topographical lineaments have consequently experienced a bay or strait stage. The time, which has elapsed since the sites were covered by seawater, is shown in Table 5-1. The shore level displacement curve presented by /Påsse 2001/ shows that the sites were shallow bays during the brackish water Litorina sea stage. All sites except Profile 3 are or have recently been used as arable land. The groundwater table has been artificially lowered, at all five profiles. Profiles 3, 4, 5 and parts of Profile 2 were most probably wetlands before drained.

The soil depth at the boreholes varied between 2.8 and 33.6 m Table 5-3. The stratigraphical interpretations from the 15 drilled sites where soil sampling were performed are presented in Appendix 1. Drawings of all boreholes are presented in Appendix 2 and photos of the sites after completion of work in Appendix 3. There are several earlier publications reporting result from drillings in the Simpevarp /Johansson and Adestam 2004ab/ and Laxemar subareas /Johansson and Adestam 2004cd/. The depth of QD in profile 2 is considerably larger than at any of the other drilled sites in the Laxemar and Simpevarp subareas. These drillings were, however, not performed in the middle of the large topographical lineaments where the deepest coverage of QD can be expected. Profile 2 is situated at the floor of one of the most pronounced valleys in the area.

5.2.1 Stratigraphy of the Quaternary deposits

The Stratigraphy of all Quaternary deposits overlying the bedrock has been described within the present investigation. The results corresponds to earlier stratigraphical results from the Simpevarp regional model area /Aggeryd et al. 1995, Risberg 2002, Nilsson 2004, Rudmark et al. 2005, Lindborg 2005/. Results from these earlier investigations are summarised in Table 5-2. It must, however, be pointed out that and the general stratigraphy shown in Table 5-2 might be disturbed at some places, due to e.g. sliding. All layers in Table 5-2 except the peat layer were found and documented during the present investigation. Profile 2 and SSM00230 are situated at or close to a glaciofluvial deposit and the stratigraphy of QD at these sites do therefore not correspond to the stratigraphy presented in Table 5-2.

Table 5-1. The time which has elapsed since the sites were covered by the sea cf /Påsse 2001/.

Profile	Time above sea level (yr)
1	5,800
2	3,500
3	3,400
4	5,500
5	4,100
Lilla Laxemar	2,900

Figure 5-12. *The topographical lineament at Profile 3 is representative for the Simpevarp regional model area. The bottom of the valley constitute of fine-grained water laid sediments and the surroundings are characterised by till and exposed bedrock. The valley has a north-east/south-west direction.*

Table 5-2. The general stratigraphy of Quaternary deposit in the Simpevarp regional model area from /Lindborg 2005/.

Quaternary deposit	Relative age
Peat	Youngest
Gyttja clay/clay gyttja	
Sand/gravel	↑
Glacial clay	
Till	↑
Bedrock	Oldest

Table 5-3. Results from the drilling in Quaternary deposits.

Profile nr	Borehole	Type	Total depth of drilling (m)	Bedrock reched
1	SSM000222	Soil/rock drilling, soil sampling, groundwater monitoring well	4.5	Yes
1	SSM000223	Soil/rock drilling, soil sampling, groundwater monitoring well	7.8	Yes
1	PSM007200	Soil/rock drilling	5.6	Yes
1	PSM007201	Soil/rock drilling	8.8	Yes
1	PSM007202	Soil/rock drilling	10.6	Yes
2	SSM000224	Soil/rock drilling, soil sampling, groundwater monitoring well	16.8	Yes
2	SSM000225	Soil/rock drilling, soil sampling, groundwater monitoring well	9.8	No
2	PSM007148	Soil sampling	8.0	No
2	PSM007149	Soil sampling	5.5	No
2	PSM007150	Soil sampling	8.0	No
2	PSM007151	Soil sampling	4.8	No
2	PSM007152	Soil sampling	3.0	No
2	PSM007153	Soil sampling	7.0	No
2	PSM007203	Soil/rock drilling	13.8	Yes
2	PSM007204	Soil/rock drilling	23.6	Yes
2	PSM007205	Soil/rock drilling	26.6	Yes
2	PSM007206	Soil/rock drilling	11.2	Yes
2	PSM007207	Soil/rock drilling	9.2	Yes
2	PSM007208	Soil/rock drilling	28.4	Yes
2	PSM007209	Soil/rock drilling	33.6	Yes
2	PSM007210	Soil/rock drilling	25.2	Yes
2	PSM007211	Soil/rock drilling	7.0	Yes
2	PSM007212	Soil/rock drilling	18.6	Yes
3	SSM000226	Soil/rock drilling, soil sampling, groundwater monitoring well	5.0	Yes
3	SSM000227	Soil sampling, groundwater monitoring well	1.4	No
3	PSM007213	Soil/rock drilling	5.6	Yes
3	PSM007214	Soil/rock drilling	5.6	Yes
3	PSM007215	Soil/rock drilling	7.0	Yes
3	PSM007216	Soil/rock drilling	5.2	Yes
3	PSM007217	Soil/rock drilling	3.8	Yes
4	SSM000228	Soil/rock drilling, soil sampling, groundwater monitoring well	8.6	Yes
4	SSM000229	Soil/rock drilling, soil sampling, groundwater monitoring well	3.8	Yes
4	PSM007218	Soil/rock drilling	3.8	Yes
4	PSM007219	Soil/rock drilling	2.8	Yes
Lilla Laxemar	SSM000230	Soil/rock drilling, soil sampling, groundwater monitoring well	4.6	Yes

Stratigraphies from six of the investigated sites are shown in Table 5-4 and the results from the drillings are presented in Appendix 1. The stratigraphies at Profiles 1 and 3 were easily defined. Sliding has disturbed the primary stratigraphy at Profile 4 (Figure 5-13) and it was therefore difficult to define the different layers. The trench at Profile 4 was situated at the base of a slope, which probably has initiated the sliding.

The stratigraphy at Profile 5 (PSM007190) differs from the one presented in Table 5-2. At that site gyttja is directly underlain by till. That stratigraphy was, however, not properly documented due to low stability of the gyttja making it too risky to study the trench properly.

It has not been possible to make detailed stratigraphical description at Profile 2 and SSM000230 since these results are entirely interpreted from drillings. /Rudmark et al. 2005/ documented disturbed the primary stratigraphy structures in one trench close to Profile 2. At that site /Rudmark et al. 2005/ interpreted the occurrence of disturbed sediments as an effect of mass movements.

The stratigraphical results presented in Table 5-4 and Appendix 1 is further discussed in the text below. It was sometimes difficult to distinguish the transition from bedrock to Quaternary deposits. At Profile 4 a strongly weathered fracture zone was recognised at the bottom of the trench (Figure 5-8 and Figure 5-9). In parts of that trench (PSM007187) it was difficult to determine if the uppermost weathered material was formed in situ or was redeposited by the Quaternary ice sheets.

The uppermost bedrock has at some places, e.g. at Profile 1, a high frequency of open fracture. At Profile 1 laminated clay/silt was found in one of these fractures, see Figure 5-14. That sediment was probably deposited before or during the accumulation of the till and indicates that the crack must be older than the latest glaciation. Laminated sediments in-between the till and bedrock was also documented by /Rudmark et al. 2005/.

Figure 5-13. *At Profile 4 Sliding has partly disturbed the primary stratigraphy and it was therefore difficult to define the different layers. The photo shows post-glacial sand (in the centre), which has been mixed with glacial clay and silt. The profile is situated close to a slope.*

Table 5-4. The stratigraphical distribution of Quaternary deposits at the investigated sites.

Profile	Depth (m)	Quaternary deposit	
PSM007160 (Profile 1)	0–0.95	Clay gyttja	Excavation
	0.95–1.20	Post-glacial sand and gravel	
	1.2–1.35	Glacial clay	
	1.35–3.2	Sandy till	
	3.2–	Bedrock	
SSM000224 (Profile 2)	0.–0.9	Artificial fill	Soil drilling
	0.9–2.5	Sand	
	2.5–4.5	Silty fine sand	
	4.5–6.0	Silty clay	
	6.0–7.0	Sandy clayey silt	
	7.0–8.0	Gravelly sandy silt	
	8.0–16.8	Gravelly sand	
PSM007171 (Profile 3)	0–0.70	Clay gyttja	Excavation
	0.70–1.30	Post-glacial gravel and stones	
	1.30–2.9	Glacial clay	
	2.9–3.75	Gravelly till	
	3.75–	Bedrock	
PSM007180 (Profile4)	0–0.90	Post-glacial sand	Excavation
	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	Excavation
	1.3–3.0	Till*	
SSM000230 (Lilla Laxemar)	0–0.2	Sandy topsoil	Soil drilling
	0.2–1.0	Silty fine sand	
	1.0–2.8	Cobble bearing gravelly sand	
	2.8–4.6	Boulder-bearing gravelly sand	
	4.6–	Bedrock	

* It was not possible to properly document this deposit.

Figure 5-14. *Laminated clay/silt in one of the bedrock fractures at Profile 1.*

The lowermost Quaternary unit is a sandy to gravelly till, which rests directly upon the bedrock. At Profile 1 the till is partly underlain by a sand/silt layer, which is resting directly upon the bedrock. The till at Profiles 1 and 3 is generally massive and matrix-supported with a normal to high degree of consolidation. The tills at Profiles 1 and 3 are rich in cobbles and stones, which are angular or very angular. Especially the lowermost till is rich in angular stones indicating very short transport distance. Laminae and lenses of sorted gravel, sand and silt occur in the till, and are unevenly distributed. At Profile 1 lumps of clay was found within the till. Also results from other studies in the Simpevarp regional model area show that the till has a generally sandy/gravelly matrix and was deposited as a lodgement till /Bergman et al. 2005, Rudmark et al. 2005/.

The fabric analyses at Profile 1 indicate that the till at that site was deposited from N10°O. The results presented in Figure 5-15 suggest that the obtained particle direction is statistically significant (see Section 4.4). At Profile 1 the direction of striae was measured on the bedrock, which was exposed beneath the till. These relatively faint striae indicate an ice movement from N15°O. Most of the earlier observed striae in the Simpevarp model area were formed by ice moving from north-west /Rudmark et al. 2005/. There is, however, one earlier observation of striae from north-east in the model area. These striae were probably formed during an earlier stage of the glaciation. It is therefore suggested that the ice moving north-east was followed by an ice moving from north-west.

The characteristics of the tills at Profiles 1 and 3 indicate deposition directly by moving glacier ice, i.e. as lodgement till. The till at Profile 3 has the higher degree of consolidation than till at the other investigated sites. The till at Profile 4 is relatively well sorted with respect to grain size and has a low degree of consolidation. These characteristics indicate that the till at Profile 4 may have been formed during the influence of melt water, i.e. an ablation till.

The till is at several sites overlain by brownish glacial clay. The uppermost clay at Profile 3 has a blue to greyish colour. It is possible that different colours of the clay (bluish and brownish) are due to diagenetic processes taking place after sediment deposition. It is notable that the glacial clay almost completely lacks varves, which commonly characterise the Baltic Sea glacial clays.

EIGENVECTORS

	l	m	n	Strike	Dip
V1=	0.983	0.175	0.064	10.081	3.670
V2=	0.152	-0.952	0.264	279.075	15.320
V3=	-0.107	0.250	0.962	113.205	74.226

EIGENVALUES

Lambda1= 68.763 S1= 0.716
Lambda2= 17.870 S2= 0.186
Lambda3= 9.367 S3= 0.098

S1/S2= 3.848
S2/S3= 1.908
S1/S3= 7.341
Ln(S1/S2)= 1.348 Ln(S2/S3)= 0.646

C= 1.994
K= 2.086
N=96

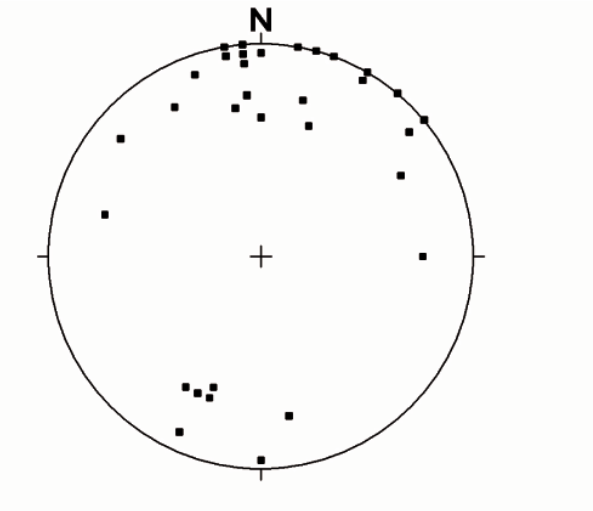


Figure 5-15. *Results from the fabric analyse in the trench at profile 1.the results indicate that the till was deposited by an ice sheet moving from N10ºE.*

At Profile 1 varves c 0.5 cm thick were, however, recorded in the lowermost part of the glacial clay. At Profile 3 fragments of limestone, probably of Ordovician age, was found within the clay. At Profile 4 a silt (Figure 5-13) layer was recognised in-between the till and glacial clay. That layer was probably deposited shortly after the deglaciation of the site. The till is absent in parts of the trench at Profile 4 and the glacial clay is resting directly upon the bedrock. There are earlier reports of varved glacial clay close to Västervik north of the Simpevarp area see e.g. /Svantesson 1999/. It is not known why the depositional environment in the investigated area has been unfavourable for the formation of varves.

A layer of sand and gravel, at some places containing stones, overlies the glacial clay. The transition from clay to sand/gravel is sharp and of erosive nature. No sedimentary structures were found in this layer, except at Profile 1 where the sand/gravel layer shows graded bedding. Streams probably deposited this layer when the sites were situated at the sea floor. The sand and gravel have redeposited during erosion of till and glaciofluvial deposits. A corresponding sand/gravel layer covers the glacial clay at many of the valleys present at the sea floor outside the Simpevarp peninsula /Risberg 2002, Elhammer and Sandkvist 2005, Ingvarson et al. 2004/. Sand and gravel may partly have been deposited by waves when the sites were situated close to the shoreline.

At Profiles 1 and 3 the sand and gravel is overlain by a bed of clay gyttja. At Profile 5 the till is directly overlain by gyttja with bands of shells, which indicates deposition in a brackish water environment. The gyttja-rich sediments were deposited during the bay stage shortly before the sites emerged from the sea. Table 5-1 shows when the investigated sites became free of seawater, which indicate the maximum age of the gyttja sediments. Organic rich sediments are currently deposited at the present bays along the coast /Elhammer and Sandkvist 2005, Ingvarson et al. 2004/. The gyttja at Profile 5 contains bands of shells from brackish water species (Erik Wijnbladh, SKB, personal comm.), which show that the gyttja was deposited in a brackish water environment. The gyttja clay from Profile 3 contains a significant amount of shells from siliceous algae (mainly diatoms). Several of the observed diatom species were common in the bays of the Littorina Sea (Anna Hedenström, SGU, personal comm.). The content of these siliceous fossils is so high that it affects the chemical and mineralogical properties of the gyttja clay.

Figure 5-16. *Sandy glacial till overlaying the bedrock at Profile 1 (PSM007162).*

Both Profile 2 and SSM000230 are situated at a glaciofluvial deposit, which is shown on the map of Quaternary deposits /Rudmark et al. 2005/. That deposit can be followed from Lilla Laxemar (Figure 1-1) to Lake Gästern in the northern part of the regional model area. Profile 2 is situated where the glaciofluvial deposits crosses one of the most prominent valleys in the area. That valley, the Mederhult zone, is part of a topographical lineament, which is denoted ZSMEW002a (see Figure 5-1). The results from the drillings (Appendices 1 and 2) suggest that the glaciofluvial material is partly underlain by till and partly rests directly upon the bedrock. The results also show that the total thickness of QD exceeds 30 metres in parts of profile 2 (Table 5-3). The uppermost sand at Profile 2 is, however, partly underlain by clay and silt Table 5-4 and Appendix 1. The sand may therefore partly be of post-glacial age and deposited after erosion of the nearby glaciofluvial material. It is possible that the glaciofluvial deposit has a larger extension the indicated by the surface map of QD. Fine-grained glacial and post-glacial sediments may partly cover the glaciofluvial deposit. The topographical lineament, the Mederhult zone, where Profile 2 is situated has an east-west direction and can be followed for several kilometres across the Simpevarp model area. /Johansson and Adestam 2004c/ have made stratigraphical investigations in the same topographical lineament west of Profile 2. The results show that there is a several metre thick layer of sand in-between the till and glacial clay. That sand may be of glaciofluvial origin. The clay in the Mederhult zone may therefore partly be underlain by glaciofluvial material. It is likely that the glaciofluvial deposit in the Mederhult zone has a high hydraulic conductivity and may consequently be important for the hydrological properties of the QD in the valley. A drilling (SSM00230) in the same glaciofluvial deposit, c 2 km south-east of Profile 2, shows that the deposit at that site is considerably thinner (4.6 m, see Appendix 1). The map of QD /Rudmark et al. 2005/ shows that the glaciofluvial deposit has a discontinuous and small surface distribution and it is therefore not likely that the deposit has a large impact on the groundwater properties of the Laxemar subarea.

During the fieldwork some observations concerning the hydrological properties of the Quaternary deposits were made. All four excavations reached below the groundwater table. It is obvious that the gravel/sand layer, situated in-between the glacial clay and clay gyttja (Figure 5-17), has high hydrological conductivity. In the trench at Profile 3 there was a significant inflow of water from that layer. That inflow had decreased during the second day of fieldwork, implying that the sand/gravel layer was almost drained. At Profile 3 the till underlying the glacial clay was not saturated with respect to water. It is consequently possible that the water in the overlying sand and/gravel layer was not in contact with the deeper groundwater. The occurrence of a sand/gravel layer has been documented at several sites in the regional model area e.g. /Aggeryd et al. 1995, Risberg 2002/ and might therefore be of significance for water transport in the valleys.

There were significant inflows of water at the transition from bedrock to Quaternary deposits both at Profiles 1 and 4 (Figure 5-18). These inflows coincide with fractures in the uppermost bedrock. Bedrock fractures may therefore be of importance for the water transport in the transition zone between bedrock and Quaternary deposits.

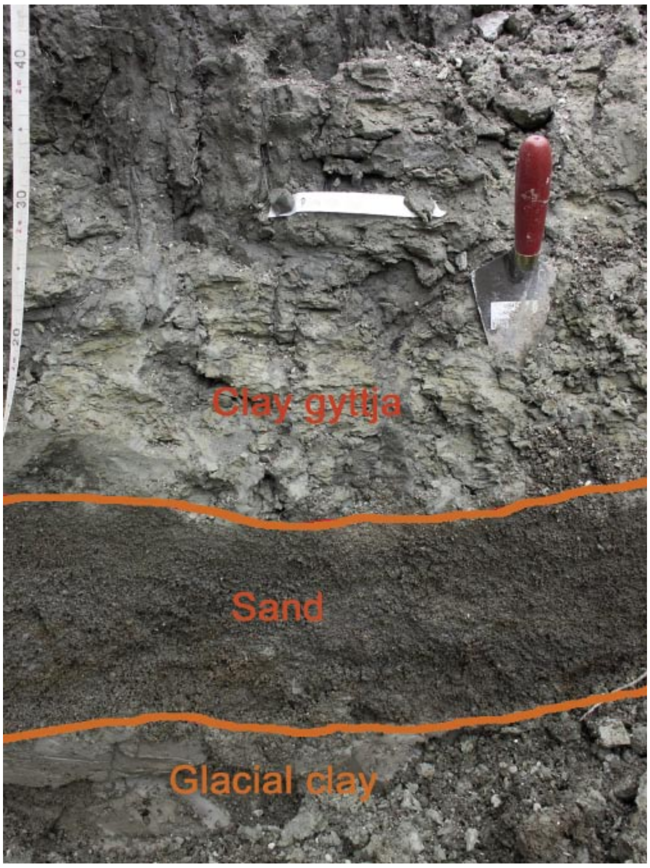


Figure 5-17. *The stratigraphical distribution of water laid sediments in the machine cut trench at Profile 1 (PSM 007160). This stratigraphy corresponds to the general stratigraphy, which has been interpreted as a result of earlier investigations in the Simpevarp regional model area (Table 5-2).*

Figure 5-18. *Inflow of groundwater at the transition between bedrock and Quaternary deposits, which was observed in the excavation at Profile 1.*

5.2.2 Drilling and sampling in soil

The composition of the soil at most locations is a thin layer of topsoil or peat underlain by sand, clay, silt and till. The composition of the till varies from gravelly sandy till to clayey till. The stratigraphical results are presented in Table 5-3 and Table 5-4 and in Appendix 1. The stratigraphical interpretations are discussed in the section above. The results from the soil/rock drillings (Table 5-3) have been compared with results from the refraction seismic measurements /Lindqvist 2004, 2005/. The total depth of QD recorded from the drillings at Profile 2 is c 10 metres deeper than the values interpreted from the seismic measurements. The seismic interpretations from profile 3 also show depths of regolith, which are a few metres shallower than these obtained from the soil/rock drillings. At Profiles 1 and 4 the soil/rock drillings and seismic interpretations show similar results.

5.2.3 Site conditions and vegetation observed during the studies of soils

The four profiles where the studies of soils were carried out (Figure 1-1, Figure 1-2, Figure 1-3, Figure 1-4 and Figure 1-5) are all located on grasslands between higher till and bedrock areas. Profile 3 is located on forest land. Soil parent material differed between the sites from clay over till to gyttja and peat. In spite of the closeness to bedrock outcrops, the regolith was fairly deep with depths down to three metres but also with shallow loose soil overburden.

Trench 1

At the sites of the deep excavations, the four trenches were opened in different directions. At Profile 1 three soil profiles (PSM-007160, PSM-007162 and PSM-007164) were investigated. This trench was located on arable and pastures and was elongated 35.5 m in east-west direction

Figure 5-19. Sampling of glaciofluvial sand at profile 2.

with a width of 7.0 m. In the western end the trench was ended in a forested stony area with bedrock outcrops. At the other end a ditch had been excavated. Depth to the bedrock varied from a few decimetres up to over three metres.

Site conditions of this trench could be characterised by fresh moisture conditions with a vegetation type of grasses. The humus form being mull and the soil formed mainly a Cambisol.

Trench 3

At Profile 3 three soil profiles (PSM-007171, PSM-007173 and PSM-007174) were investigated. This trench was located on forest land, currently mainly as a clear-cut, between two bedrock outcrops furnishing shallow soils in both ends of the trench. The elongation was in a NW–SE direction (305°; 125°) with a length of 26.5 m and a width of 12.5 m.

The site conditions varied along the trench but moisture properties could mainly be characterised as fresh-moist while vegetation conditions were influenced also from the thickness of the regolith. Vegetation was studied along a 50 m long transect including the trench in the middle. The site conditions furnished a lichen and blueberry type in the north-west 18 m, i.e. c 6 m of the trench, turning into a fresh mosses and broadleaved grass type in the south-east 32 m, i.e. 20 m of the trench.

Trench 4

At Profile 4 three soil profiles (PSM-007180, PSM-007181 and PSM-007183) were investigated. This trench was located on pastureland between two higher bedrock outcrops. The trench was located in the northern part of this pasture and was bordering to upland bedrock in the north while a ditch was slightly beyond the southern edge. The length of the north-south elongated trench was 18 m and the width was 15 m.

The site characteristics showed a fairly dry grassland. Vegetation was studied in a 100 m long transect including the whole pasture. In the trench section, vegetation was characterised by fresh mosses in the bottom layer and broad-leaved grasses in the field layer.

Trench 5

At Profile 5 one soil profile (PSM-007190) was investigated. This trench was located in a small topographical lineament between higher bedrock outcrops. The trench boarded to the southern bedrock and formed a large pit of size 5.5 m×7.5 m. The land-use was for grazing but had for some period earlier been used as arable with ploughing.

Site conditions could be determined to moist or fresh-moist with an obvious groundwater level at the excavation time on 0.6 m below ground surface. Vegetation type was fresh mosses and broadleaved grasses.

Soil conditions in all trenches

A variety in soil types occurred, mainly being Cambisol, Regosol and Histosol/Gleysol. This means the soils did not totally reflect the large areas of Leptosol and Regosol found in the soil and site type inventory carried out in 2004 /Lundin et al. 2005b/. However, this could be expected as the locations of the trenches were selected to low-lying areas in small valleys. There often arable and pastures existed and soil material deposited in such locations would be more fine textured as compared to the upslope material of till in shallow regolith on bedrock. In the total Oskarshamn investigation area soil types, to a large extent, were in classes LP and PZ/RG but the trench soils could mainly be in classes UM/GL-a, PZ/RG and UM/GL /Lundin et al. 2005b/. Humus forms would in three trenches be mull and in one a mor 2 type.

Vegetation conditions in all trenches showed fresh mosses in the bottom layer and broad-leaved grasses in the field layer. In the open land in trench locations hardly any trees occurred but in the vicinity both conifers and deciduous trees could be found. Spruce, pine, oak, birch, maple, aspen and salix were most common (Appendix 4).

5.2.4 Humus layer thickness

The thicknesses of the humus layer were determined in the profiles. Only in profile 3 there is a proper organic layer of mor 2 type being 18 cm. The other trench profiles furnished mull humus forms gradually turning into pure minerogenic soil material. (Table 5-5).

5.2.5 Stoniness

Content of stones and boulders in the soil have significant influence on soil hydrology and soil chemistry. Information on such content is difficult to obtain. In the profile investigations, two methods were used. One was based on the rod penetration method /Viro 1958/ and the other being actual measurements on the soil profile wall.

Problem with the rod method is a fairly poor validation to actual contents. However, in this investigation the same equation was used for the two methods. Validation was only of the penetration depth where the Viro method used the rod penetration and the actual measurements on the trench wall would be actual ocular depth measurements to the first stone in the profile. Possibly, the rod could pass small stones (2–6 cm) especially in the upper fairly loose soil material. This would mean a greater penetration depth and an underestimation of the stoniness. This was also what was found while the rod method gave a stoniness of 10% on average for three trenches while wall measurements ended up with 36% (Table 5-6). A further deviation was the trench width. The rod penetration was carried out along a centre line while the wall measurements were done on the trench wall, a few metres on the side of the central line. In trench 5 no determinations were made due to the absence of stones in the top soil profile.

Table 5-5. Thickness of the top organic or mull humus layer in the four trenches in the Oskarshamn area.

	Top mull/mor horizon (cm)
Trench 1, PSM007161, mull	22
Trench 3, PSM007174, mor 2	18
Trench 4, PSM007183, mull	10
Trench 5, PSM007190, mull	37

Table 5-6. Stoniness in the trenches. Rod penetration depth and corresponding stone volume and wall measurements with corresponding stone volume.

Profile	Rod depth, cm	"Rod" stone volume, %	Wall depth, cm	"Wall depth" stone volume, %
1	24	12	12	39
3	19	11	11	41
4	26	8	17	28

5.2.6 Root depth

The depth of fine and coarse roots was investigated in the trenches. Determinations were made in three profiles in trenches 1, 3 and 4 and in one profile in trench 5. Fine roots (< 2 mm) were found in most locations and the depth varies from 34 cm to 241 cm. Most of the roots reach between 30 cm and 100 cm. Coarse roots reach slightly less deep and the average for these were 79 cm while the fine roots reach 94 cm on average for all four trenches (Table 5-7).

5.2.7 Soil type

In the four trenches, the soil types were determined and the trench walls provided possibilities to get a continuous semi-quantitative distribution of the soils. These, being fairly young in the Oskarshamn area, had formed ordinary soil types but not developed totally. In trench 1, the bedrock thickness varied considerably and in the thicker regolith a Cambisol occurred while where it was a thin regolith, it furnished (Table 5-8). The distribution along the trench 1 showed 79% Cambisol and 21% Leptosol (Figure 5-20). In trench 3, the edges of the trench close to the upslope bedrock furnished Leptosol accounting for 26% of the trench length while Regosol dominated with 74% (Figure 5-20), mainly found in the middle trench part (Table 5-8). In trench 4, Regosol made up 100% of the soil profiles but showed partly almost a Podzol profile (Figure 5-20).

Trench 5, being mainly a large pit under fairly moist conditions showed relatively high organic content in the upper metre with c 18% to be compared to 1–5% in the other profiles. However, in the upper soil horizon, mineral particles occurred and could be an effect of mechanical anthropogenic measures but also the inclusion of deeper soil material in the soil horizons. The fairly high organic content, however, indicates a histic horizon that should imply a Histosol and a top peat layer. However, in true peat soils the carbon content reaches c 505 and trench 5 profile is on the lower limit for peat. In deeper layers, c 100 cm, limnic properties occur but already in 0.6 m depth reduced conditions were found. The profile could be considered either a Gleysol or a Histosol but probably the top horizon profile should be regarded a Histosol (Figure 5-20).

Soil profile type varied within two of the trenches 1 and 3 while there were only one soil type within each of the other two trenches, 4 and 5. One typical soil profile developed in each of the sites show a Cambisol in trench 1, a Regosol in trench 3 and 4, and a Histosol (Gleysol) in trench 5 (Figure 5-21, Figure 5-22, Figure 5-23, Figure 5-24).

Table 5-7. Root depths in the four trenches in the Oskarshamn area. In trenches 1–4 three profiles were investigated and the range for the three profiles is presented together with the average depth. In trench 5 only one profile was determined.

Trench	Coarse root depth, cm range; mean	Fine root depth, cm range; mean
1	25–82; 48	34–83; 56
3	42–77; 82	60–79; 68
4	98–201; 150	98–241; 168
5	28	64

Table 5-8. Soil type distributions in trenches 1–5 of the Oskarshamn area.

Site	Length of the trench, m	Soil type, %			
		Histosol	Leptosol	Regosol	Cambisol
Profile 1	33	0	21	0	79
Profile 3	26.5	0	26	74	0
Profile 4	16			100	
Profile 5	7	100			

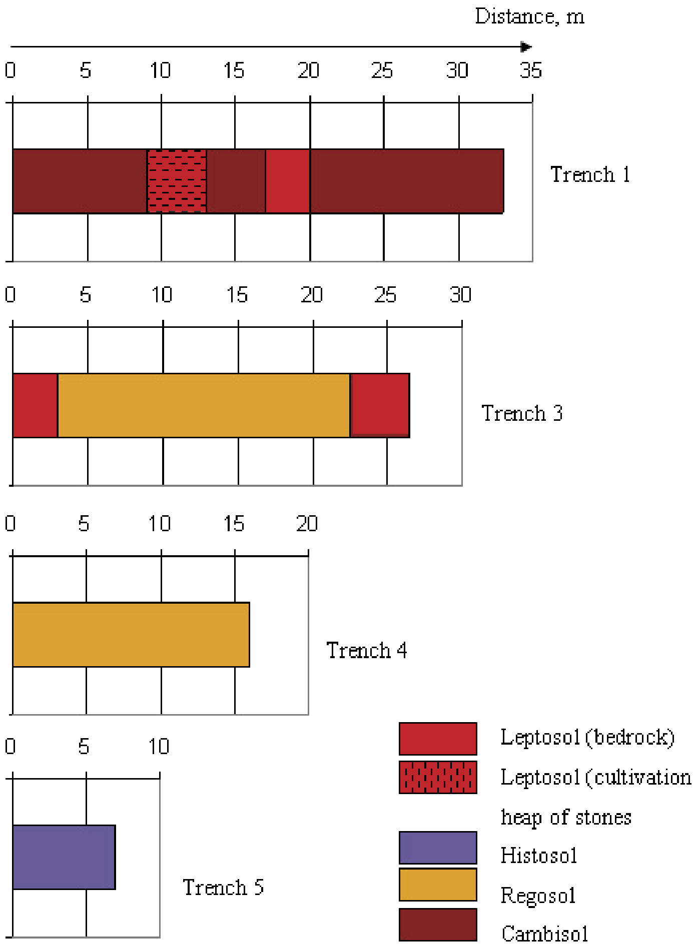


Figure 5-20. Soil type distributions along the four trenches in the Oskarshamn area.

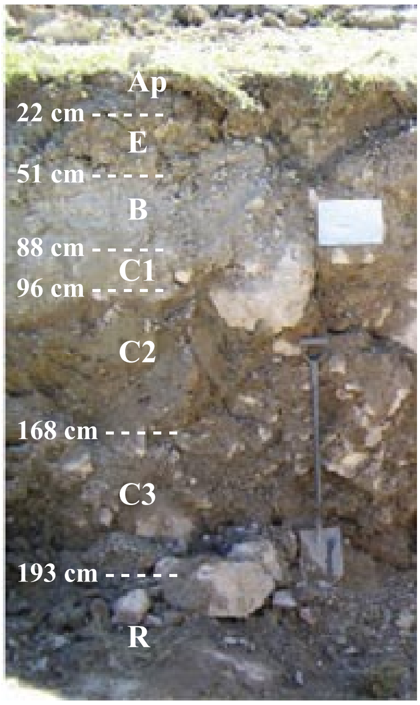


Figure 5-21. *The typical Cambisol soil profile in trench 1 (PSM-007161) with a top mull layer of 22 cm. Under this a cambic horizon to 96 cm dominated by clay but including stones and boulders. Also layers of silt and sand was found between 88 and 96 cm. Below this down to c 120 cm gravely and sandy out-washed till had been deposited. Further down there again mainly clay.*

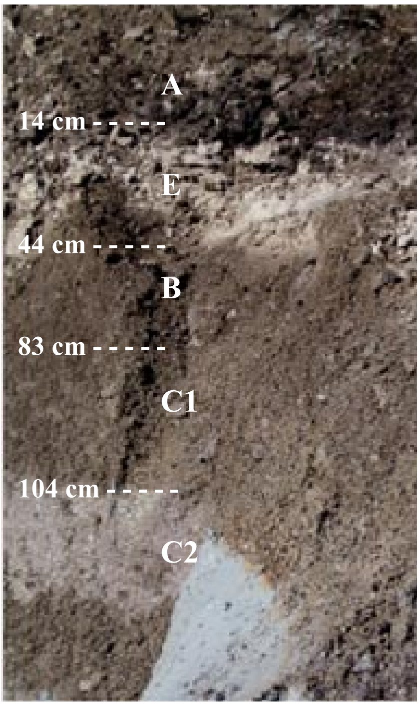


Figure 5-22. *A typical soil profile in trench 3 (PSM007174) being a Regosol with an organic Mor 2 layer of 14–18 cm. Below this an albic E horizon with silt in layers 0–44 cm, then a B-horizon of coarse postglacial sand in 44–83 cm continuing weaker to 104 cm and with a C-horizon in glacial clay; 104+ cm.*

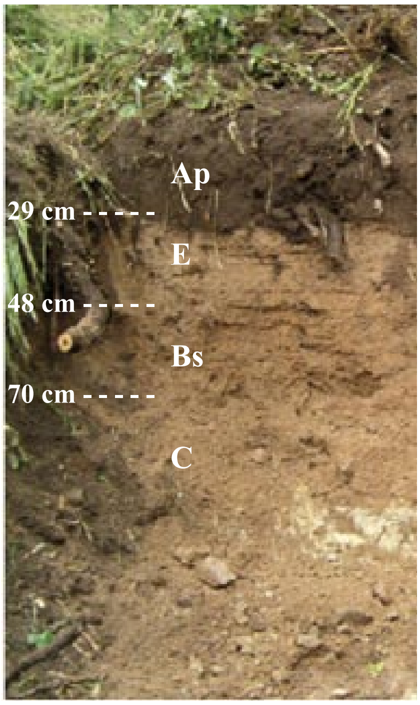


Figure 5-23. *The Regosol profile in trench 4 (PSM-007183) with a top mull horizon of 10 cm followed by an albic silt horizon to 15 cm and a sandy horizon to 30 cm, continuing to c 74 cm. A Spodic B-horizon was found between 29 and 48 cm. The sandy and gravely material continued to 88 cm and below a clay material was found.*

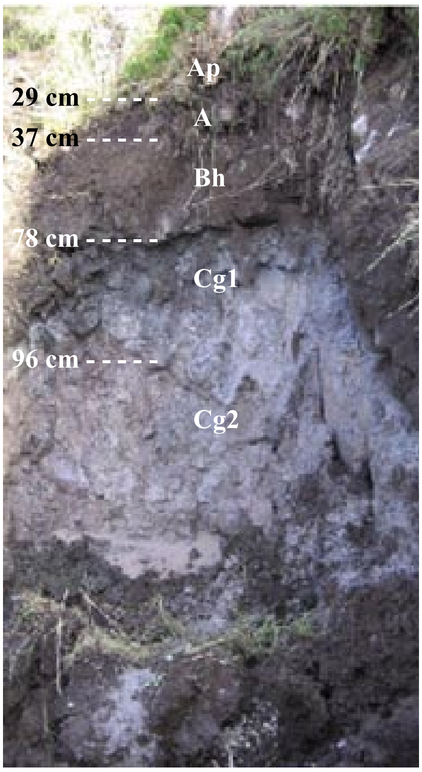


Figure 5-24. *The special soil profile of trench 5 (PSM-007190) forming a Histosol, but having characteristics resembling also a Gleysol. In the top one metre there was high carbon content (c 18%) and right below this a shell layer was found and further down first gyttja and then a clay soil continued.*

5.3 Results from chemical and physical properties of soils and Quaternary deposits

5.3.1 Grain size and $CaCO_3$ content

Twenty samples were analysed with respect to grain size composition. All cumulative grain size curves are presented in Appendix 5. A summary of the samples and their names according to SGU's nomenclature is presented in Table 5-9. Table 5-10 summarises the grain size analyses from six till samples. The grain size composition of these till samples is similar to what has been observed during earlier investigations in the Simpevarp regional model area e.g. /Rudmark et al. 2005/.

The clay content in the 8 analysed clay samples varies between 60 and 25%. The analysed samples are too few for a statistical evaluation of the clay contents of the different clay types. Earlier investigation have, however, shown that the clay content of the glacial clays varies between 50–75% (average 65%). The same studies show that the gyttja and gyttja clay have an average clay content of 30% /Nilsson 2004, Rudmark et al. 2005/.

The analysed two till samples from Profile 3 contains 4.5 and 2.1% calcium carbonate. There are no earlier observation of till containing calcite in the Simpevarp model area e.g. /Rudmark et al. 2005/. The provenance of calcium carbonate is not known. The closest limestone area is situated c 25 km east of Simpevarp at the floor of the Baltic Sea. The limestone may alternatively emanate from Östergötland almost 150 km north-west of the Simpevarp area. The glacial clay lacks or almost lacks calcium carbonate, which is in accordance with earlier results from the Simpevarp area /Nilsson 2004/. Bands of shells (containing $CaCO_3$) were found in the gyttja at Profile 5. The carbonate analyses shows that the fine-grained matrix of that gyttja lacks $CaCO_3$.

Table 5-9. The samples analysed for grain size and chemical composition.

Id-code	Depth (m)	Quaternary deposits
PSM007160	0.7–0.8	Gyttja clay
PSM007160	1.0–1.1	Gravelly sand (post-glacial)
PSM007160	1.25–1.3	Glacial clay
PSM007160	2.2	Gravelly till
PSM007162	1.0–1.2	Sandy till
PSM007163	1.3	Gravelly till
PSM007170	1.2	Clay
PSM007171	0.5	Clay gyttja
PSM007171	1.25	Gravelly sand (post-glacial)
PSM007171	1.4	Glacial clay
PSM007171	1.8	Glacial clay
PSM007171	3.2	Gravelly till
PSM007173	1.5	Gravelly till
PSM007180	0.3	Sand (post-glacial)
PSM007180	1.4	Glacial clay
PSM007180	2.3	Clayey silt
PSM007180	2.5	Gravelly till
PSM007190	1.1–1.3	Gyttja
SSM00224	12.0–13.0	Sandy gravel (glaciofluvial)
SSM00225	2–2.8	Sand (glaciofluvial)

Table 5-10. The average grain size composition of material < 20 mm, in the analysed 6 till samples.

	Average	Max	Min	Standard dev.
Gravel (%)	41.8	75.2	28.9	17.3
Sand (%)	46.9	60.2	18.6	15.3
Fine material (%)	11.2	23.7	5.6	6.9
Clay (%)	3.1	4.6	1.8	0.9

5.3.2 Density, porosity and soil moisture content

The compact density in the profiles showed lower values in the upper soil layers with 1.9 to 2.5 g/cm^3 dependent on the organic content. In deeper layers the values reached normally 2.6 to 2.7 g/cm^3 to be compared with the ordinary silica material being on 2.65 g/cm^3. However, deviations were small (Appendix 6).

Dry bulk densities were slightly lower in the top mineral soil layers with values between 0.9 g/cm^3 and 1.2 g/cm^3 as compared to the deep layers with densities between 1.6 g/cm^3 and 2.1 g/cm^3. In organic layers or those mineral layers with high organic content the bulk densities were lower with values on 0.2–0.6 g/cm^3 (Figure 5-25 and Appendix 6). Such values were also found in forested till soils in region Bergslagen but there the highest densities were found up to 2.3 g/cm^3 /Lundin 1982/.

Porosities could be considered fairly high with values in the upper soil layers of 50–80%, decreasing with depth to 30% in some layers at c 1 m depth (Figure 5-25 and Appendix 6). Mainly these values could be considered rather high compared to the ordinary till soils in Sweden /Lundin 1982, Lundin et al. 2005a/. The often occurring clay content in the soil provided higher porosities as compared to till or out-washed till. This could be noticed in the profile of the Oskarshamn trenches. One pattern could be observed as the layers between 0.8 m and 1.2 m in several profiles showed a lower porosity and water content as compared to both higher and lower layers.

5.3.3 Water retention conditions and soil moisture content

At the time for soil sampling, soil moisture content was ordinary fairly close to field capacity. In a few layers, water content was high and in deep layers also saturation occurred (Appendix 6).

Water content in relation to retention showed similar patterns with higher total water contents and stronger decrease with suction in the upper soil layers compared to deeper ones. In trench 1, profile PSM-007160A, the layers down to 0.5 m show similar retention relationships with the deeper 0.8 m and 1.4 m but with slightly higher water contents. The layer 1.2 m deviates with low water content (Figure 5-26 and Appendix 6). In the trench 3, profile PSM-007171A, show rather high water contents and strong retention in all layers but 0.5–0.8 m where water content is lower with at saturation 30–40% and below 10% at a pF-value of 2 to 2.7 (Figure 5-26 and Appendix 6).

Similar conditions was observed for the other two trenches but in trench 4 the upper 0.5 m layers showed stronger decrease in water content (28–37 vol-%) with suction as compared to deeper layers where the water content decrease was only 5–16 vol-% (Figure 5-27 and Appendix 6). In trench 5, water content was high in the upper 1.2 m with a decrease with suction of 20–35 vol-% while the deep layers on 2–3 m depth showed lower water content at saturation and small decreases with suction only making up 10–14 vol-% (Figure 5-27 and Appendix 6).

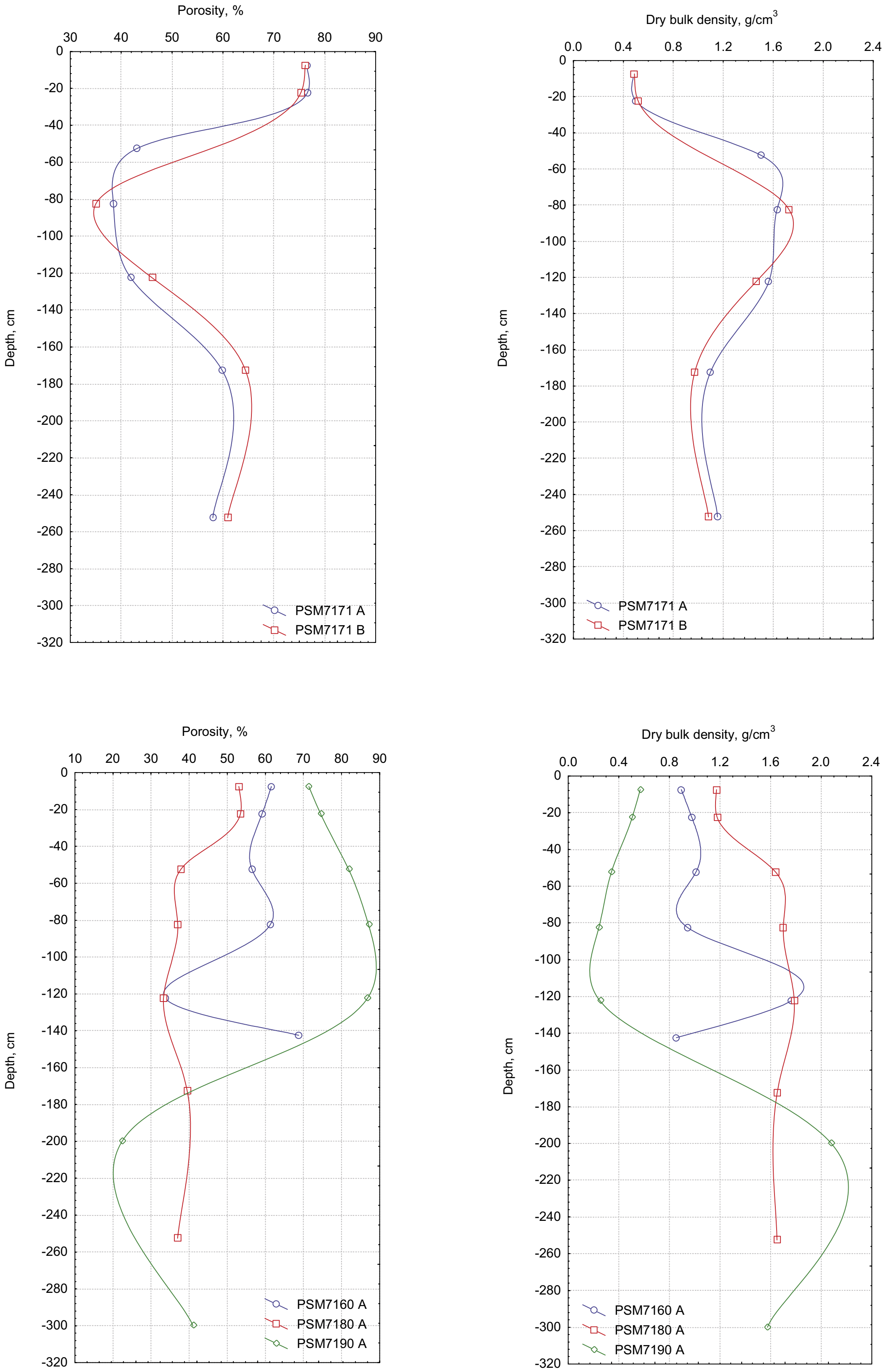


Figure 5-25. *Porosity (left) and dry bulk density (right) in the trenches, profiles PSM-007171 A and B and PSM-007160, 7180 and 7190. The depth zero (0) level is the mineral soil surface.*

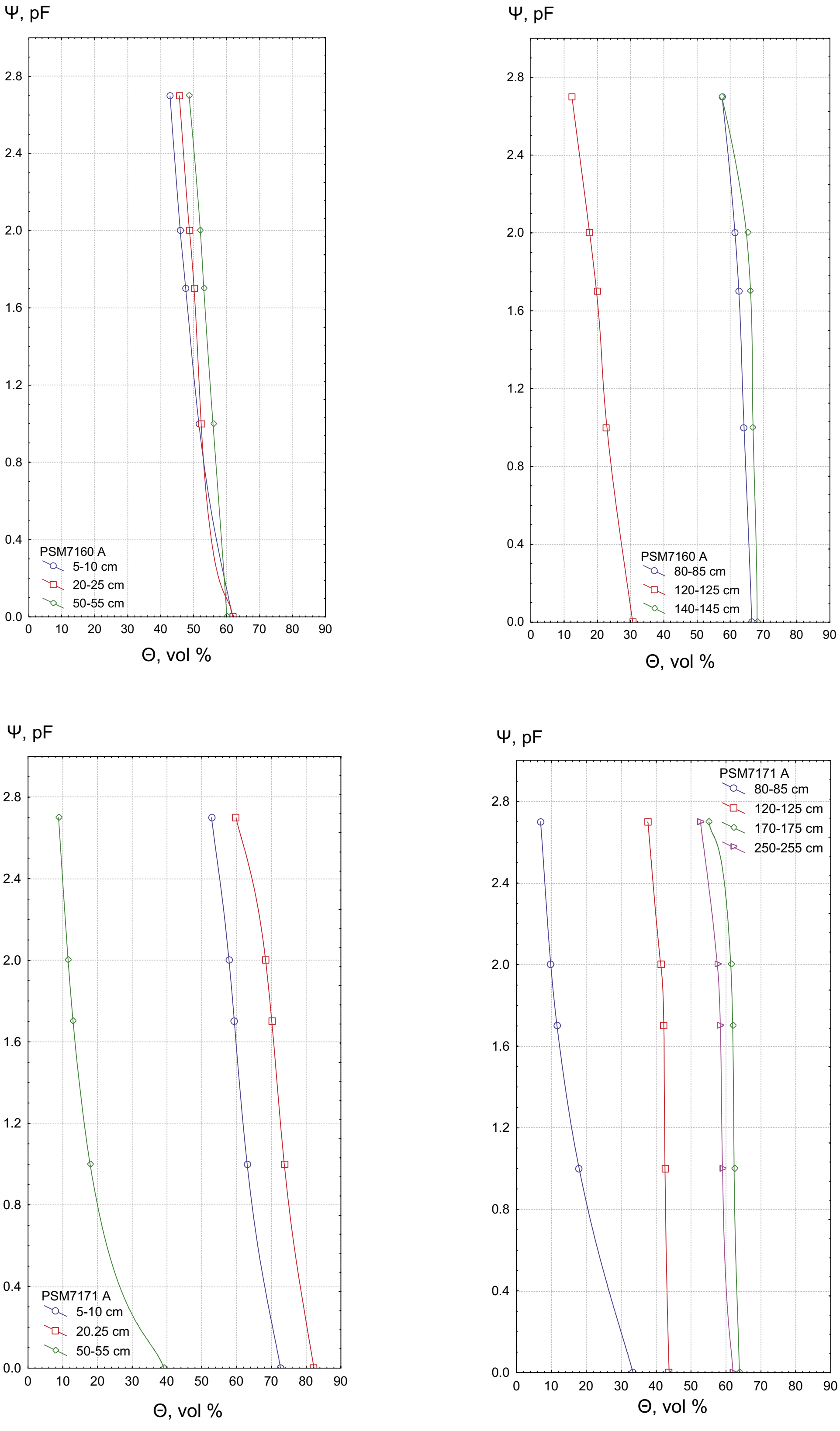


Figure 5-26. *Soil water retention curves for six layers in profile PSM-007160, trench 1 and seven layers in profile PSM-007171, trench 3. (pF values are the negative logarithm of water suction in cm water pressure.)*

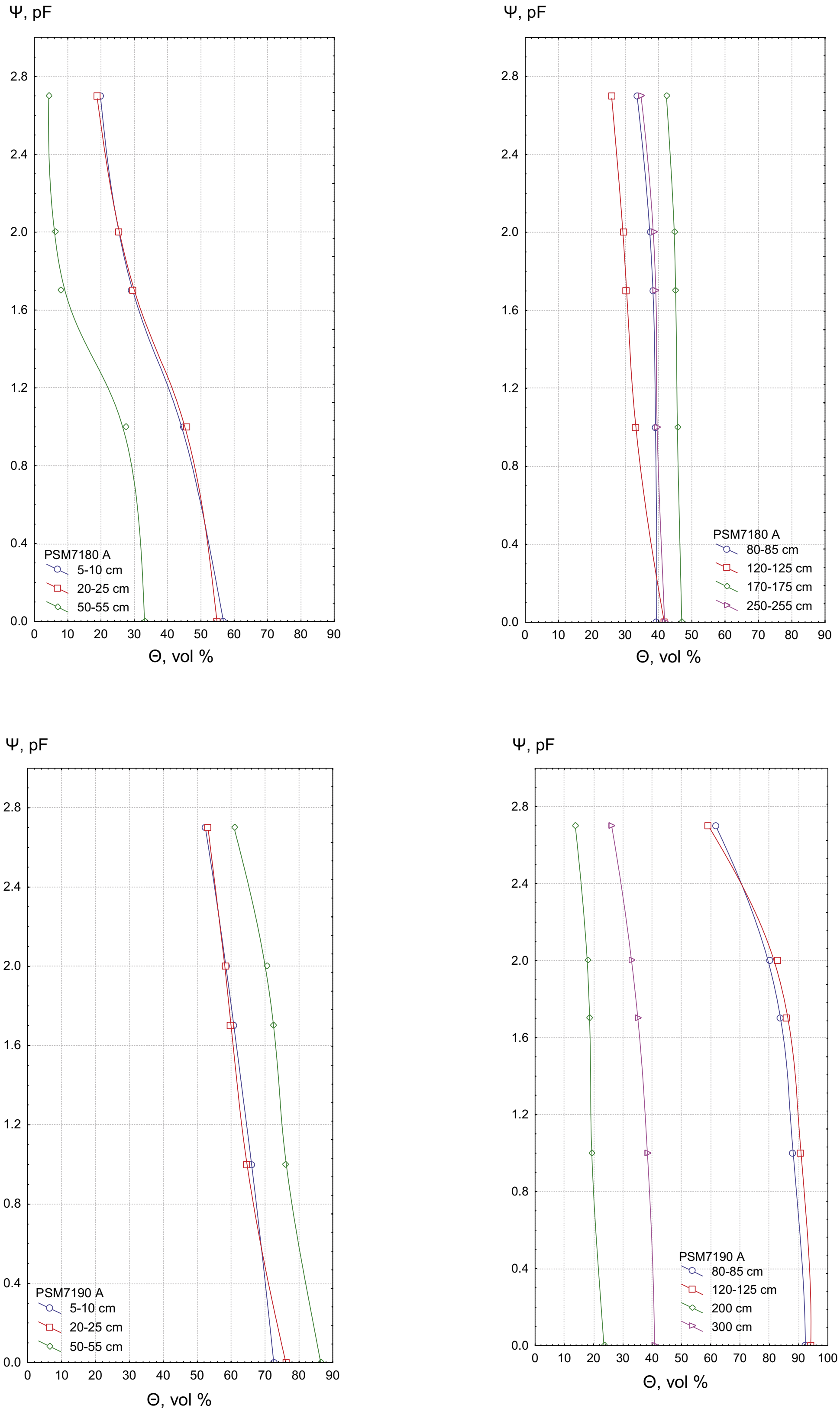


Figure 5-27. *Soil water retention curves for seven layers in both profile PSM-007180, trench 4 and in profile PSM-007190, trench 5. (pF values are the negative logarithm of water suction in cm water pressure.)*

5.3.4 Hydraulic conductivity

The hydraulic conductivity provides information on the possibilities for water to flow through soil and bedrock materials. With knowledge on such conductivity it is possible to calculate water and element flows. Investigations on hydraulic conductivity have mainly been carried out on water bearing formations where flows are considerable, such as glaciofluvial deposits. In such geological formations rather high conductivity values have been measured. In till soils and those with high clay content, such as those in the trenches of the Oskarshamn area, lower values could be expected. A fairly small number of investigations have been made in such soils and resulted in values being relatively high in the top soil layers with 10^{-5}–10^{-4} m/s and a strong stratification with soil depth to reach values on 10^{-8}–10^{-7} in the deep layers at 2–3 m /Lundin 1982, Lind and Lundin 1990/.

In the Oskarshamn and Forsmark investigations knowledge also of the deep layer hydraulic conductivity is crucial in the determinations of element transport from the bedrock to the surface water systems. Therefore, special determinations were made in the trench profiles and conductivity measured on the undisturbed samples taken. In the Forsmark area, the conductivity values showed considerable variation with relatively high conductivities in the upper soil layers (2–4×10^{-5} m/s) and with a considerable decrease with depth to values below 10^{-7} m/s already at 0.5 m /Lundin et al. 2005a/.

The hydraulic conductivity of the profiles in the trenches of the Oskarshamn area showed mainly the ordinary pattern for till soils but even stronger decrease in conductivity with depth as compared to other locations (Figure 5-28 and Appendix 7). In trench 1, higher conductivities were found between 1.0 m to 1.5 m as compared to the other three trenches. A few high values were found in the upper layers of trench 4 and 5 (Figure 5-28 and Appendix 7).

5.3.5 Results from the qualitative XRD analyses

Till sample PSM007162/1.0–1.2

Matrix (grain size fraction < 2 mm)

The best representation of major minerals in the samples is obtained by analysis of random oriented specimen (Figure 5-29).

Quartz, plagioclase ("calcian albite" = oligoclase), potassium feldspar (microcline) are major minerals in the till matrix as is indicated by large peaks in the X-ray diffractogram which fit to lines for these minerals from the /PDF 1994/ database. Peaks from hornblende, illite, vermiculite, chlorite and kaolinite are also present in the diffractogram. The yellow lines show the positions of peaks of the standard (ZnO).

Clay fraction (grain size fraction < 2 µm)

To identify clay minerals preferred orientation of specimen has to be applied for the analysis. Peaks from the layered silicates (clay minerals and micas) are thereby enlarged (Figure 5-30).

Characteristic for the mineralogy of the clay fraction is a high content of clay minerals. Illite, kaolinite, chlorite, vermiculte and a swelling mineral which expand when EG-saturated have been identified. The swelling mineral has been interpreted as an interstratified illite/vermiculite. When heated vermiculite layers contract to the spacing of illite (see red trace in Figure 5-30). The presence of kaolinite has been documented after resolution of chlorite by acid treatment (see turquoise diffractogram in Figure 5-30). Quartz and feldspars are also present in the clay fraction.

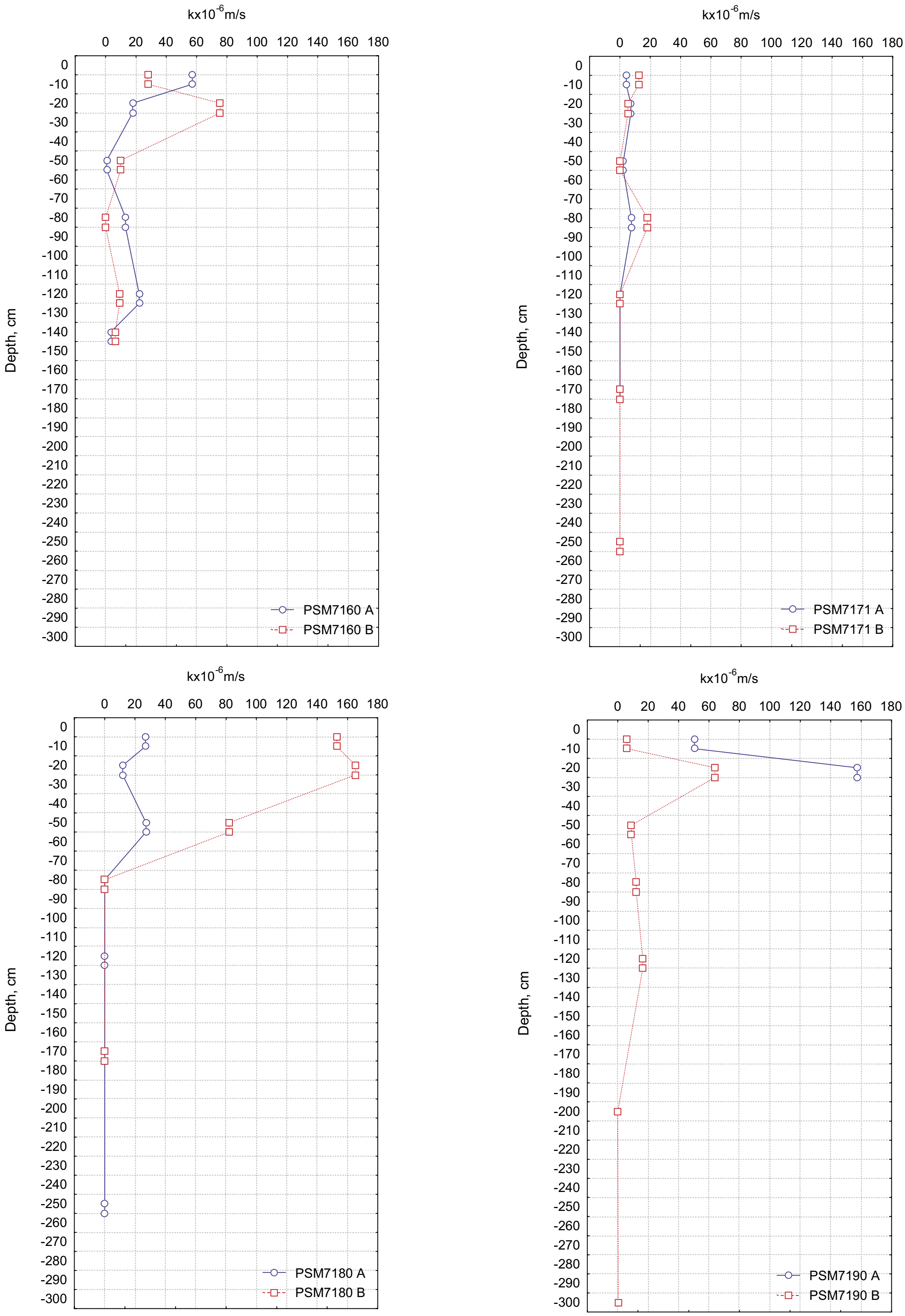


***Figure 5‑28.** Hydraulic conductivity in profiles PSM‑007160, PSM‑007171, PSM‑007180 and PSM‑007190 A and B in trenches 1, 3, 4 and 5 of the Oskarshamn area. The two replicate samples are included. Observe the scale on the conductivity axis.*

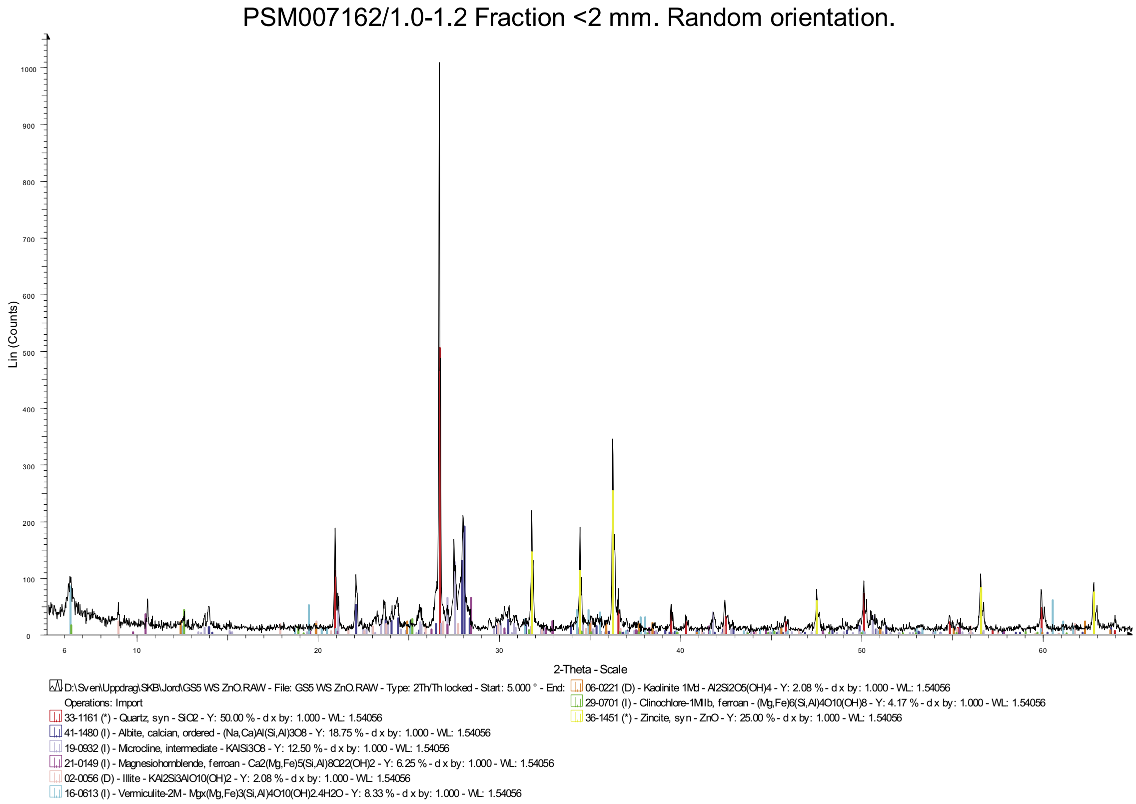


Figure 5-29. *X-ray diffractogram of matrix fraction of sample PSM007162/1.0–1.2. The analysis was performed with random orientation of the crystals.*

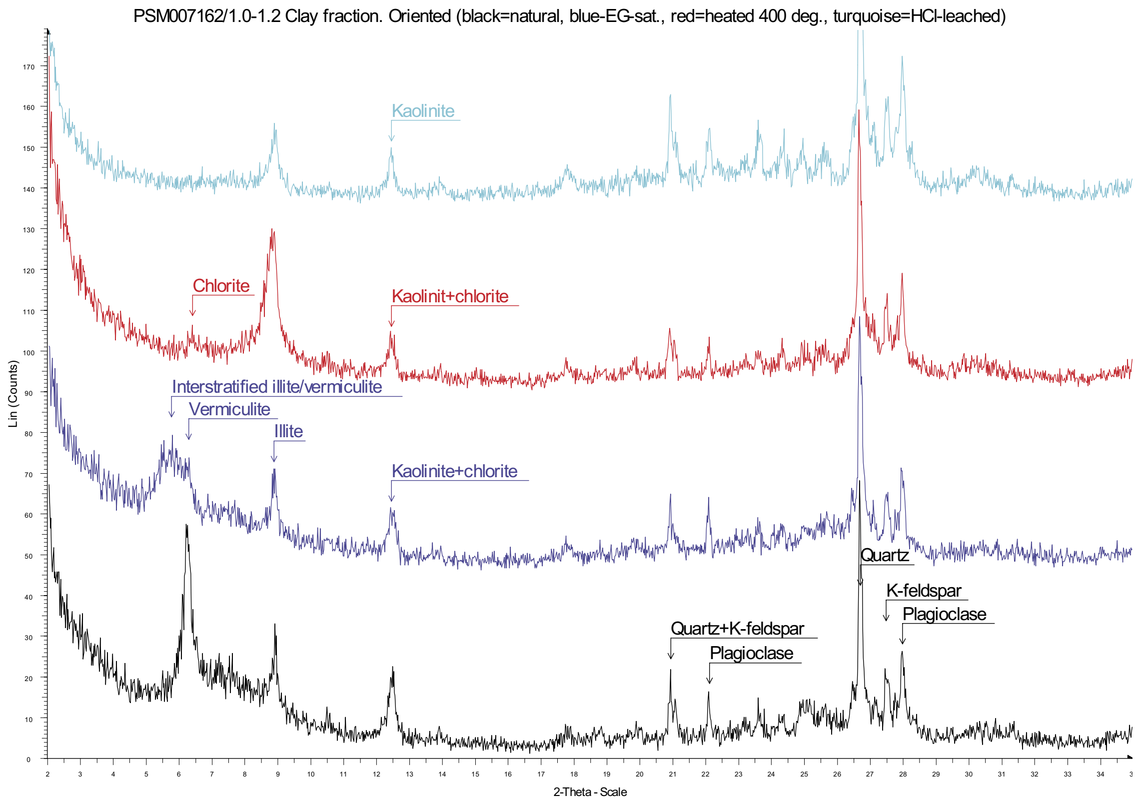


Figure 5-30. *X-ray diffractograms of < 2 µm fraction of sample PSM007162/1.0–1.2. The analysis was performed with preferred orientation of the crystallites.*

Till sample PSM0071171/3.2

Matrix (grain size fraction < 2 mm)

Quartz, plagioclase and potassium feldspar are major minerals in the matrix. In addition calcite, hornblende, illite, chlorite and vermiculite were identified (Figure 5-31). The yellow lines show the positions of peaks of the standard (ZnO).

Clay fraction (grain size fraction < 2 µm)

Illite and chlorite are predominant in the clay fraction of this till sample. Minor amounts of vermiculite, interstratified illite/vermiculite and kaolinite are present (Figure 5-32). Quartz and feldspars are also present in the clay fraction.

Till sample PSM0071180/2.5

Matrix (grain size fraction < 2 mm)

Quartz, potassium feldspar and plagioclase are major minerals in the matrix. Peaks from illite and chlorite are also present in the X-ray diffractogram (Figure 5-33). The yellow lines show the positions of peaks of the standard (ZnO) added to the sample.

Clay fraction (grain size fraction < 2 µm)

Similar to sample PSM0071171/3.2 illite and chlorite are the predominant minerals in the clay fraction. Interstratified illite/vermiculite and kaolinite are present in smaller amounts (Figure 5-34). As usual quarts and feldspars are also found in the clay fraction.

Clay sample PSM007160/0.7–0.8

Clay fraction (grain size fraction < 2 µm)

The best representation of major minerals in the samples is obtained by analysis of random oriented specimen. The X-ray diffractogram show the presence of quartz, plagioclase, potassium feldspar, vermiculite, chlorite and illite (Figure 5-35). The yellow lines show the positions of peaks of the standard (ZnO).

To facilitate clay minerals identification the sample has been analysed with preferred orientation of the crystallites. Peaks from illite, chlorite, vermiculite, illite/vermiculite, quartz and feldspars were found (Figure 5-36).

Clay sample PSM007160/1.25–1.3

Clay fraction (grain size fraction < 2 µm)

Peaks from quartz, plagioclase, potassium feldspar, illite, chlorite and vermiculite were found in the X-ray diffractogram (Figure 5-37). The yellow lines show the positions of peaks of the standard (ZnO).

The more diagnostic analysis for the clay minerals also displays the presence of kaolinite and vermiculites of different kinds. In addition to the illite and chlorite there may be interstratification of high charged and low charged vermiculites. Peak from quartz and feldspars are also present (Figure 5-38).

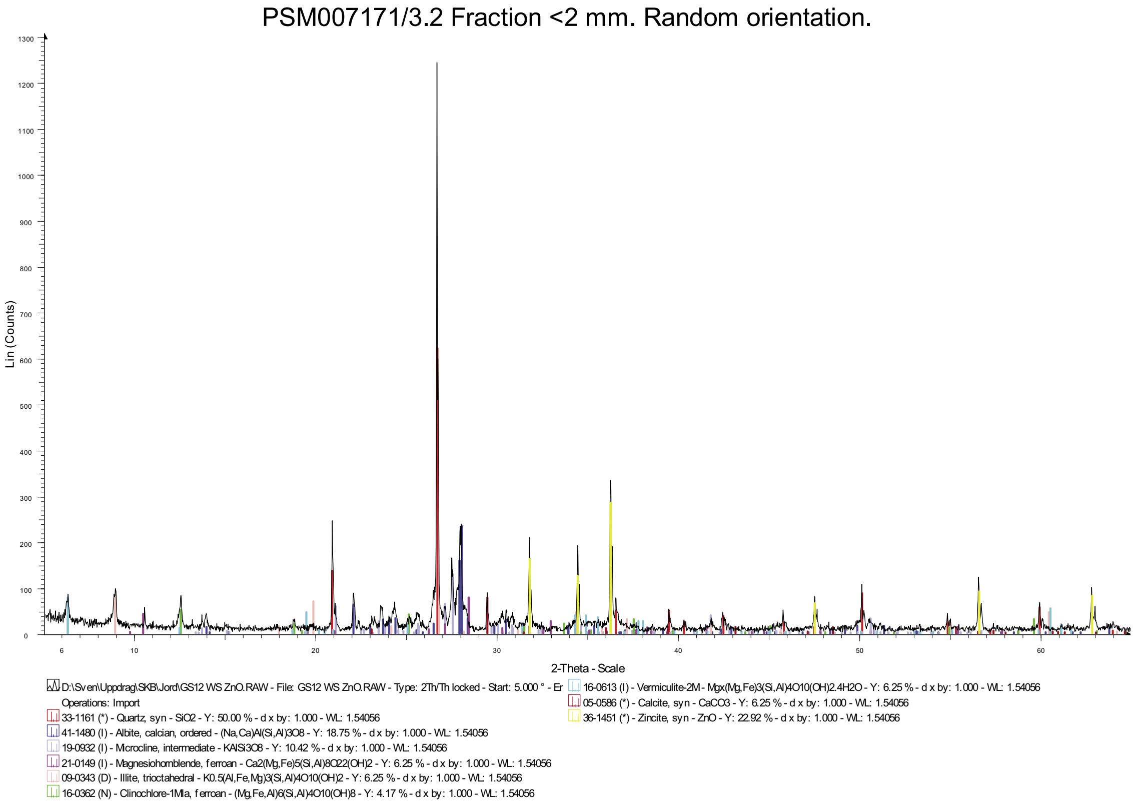


Figure 5-31. *X-ray diffractogram of matrix fraction of sample PSM007171/3.2. The analysis was performed with random orientation of the crystals.*

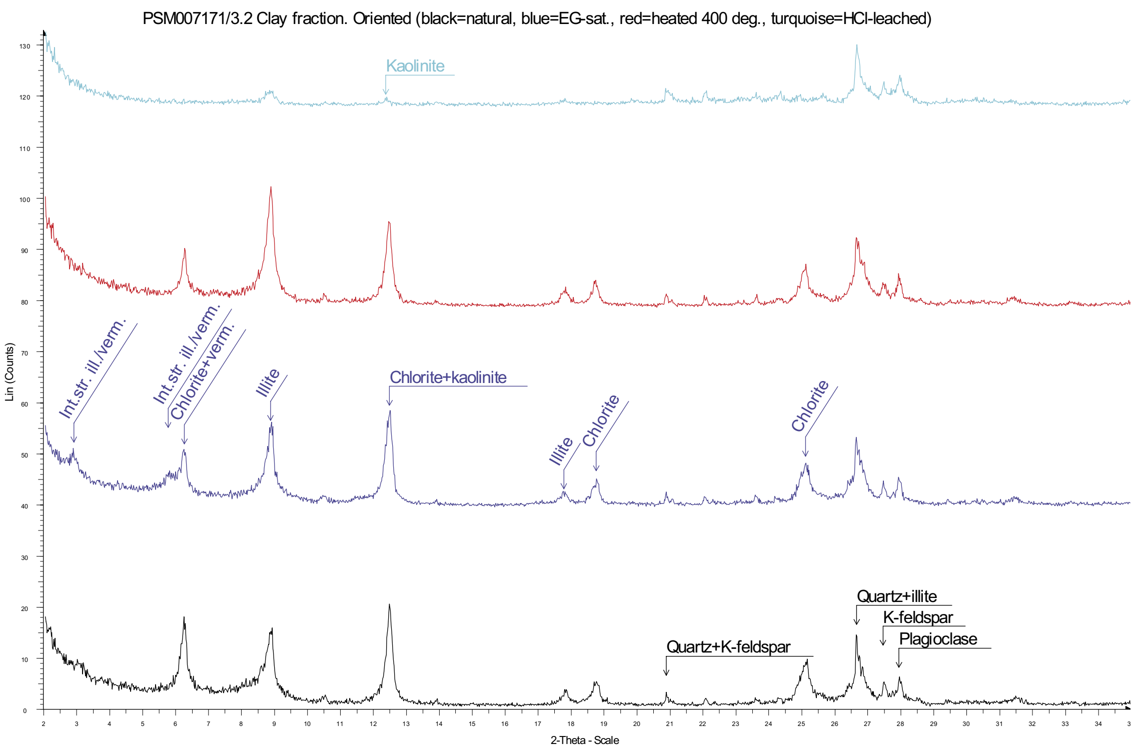


Figure 5-32. *X-ray diffractograms of <2 µm fraction of sample PSM007171/3.2. The analysis was performed with preferred orientation of the crystallites.*

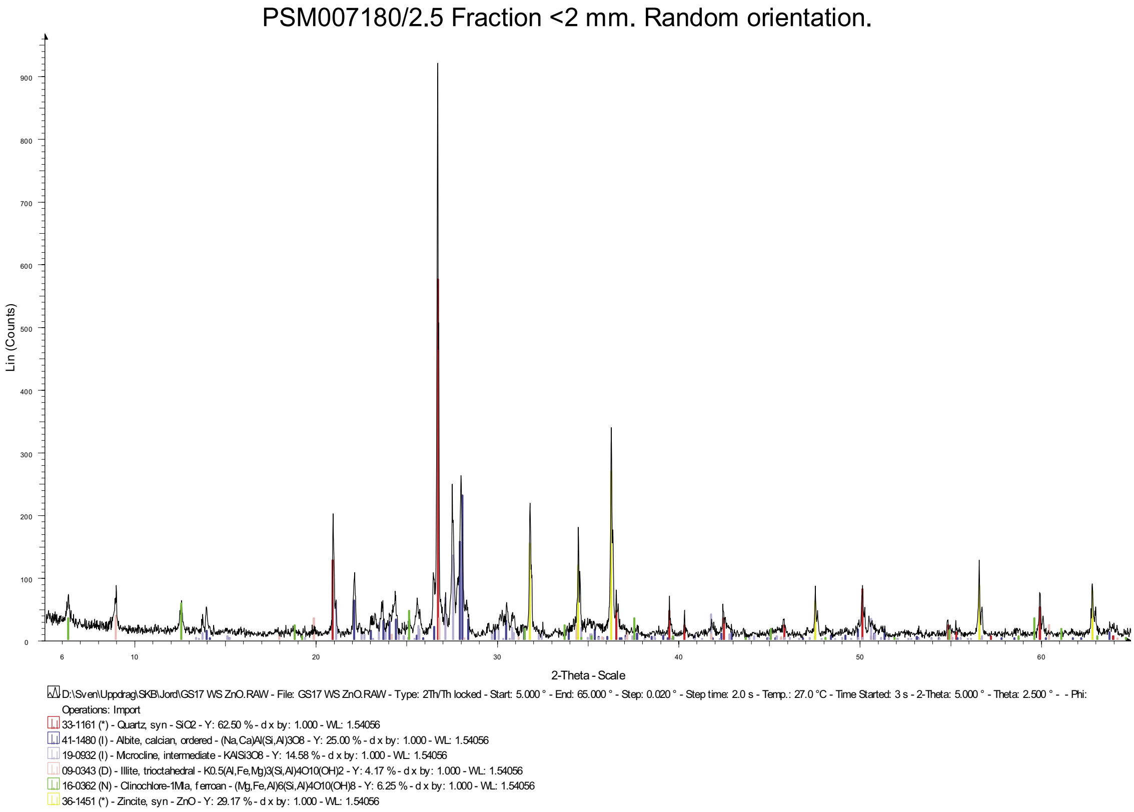


Figure 5-33. *X-ray diffractogram of matrix fraction of sample PSM007180/2.5. The analysis was performed with random orientation of the crystals.*

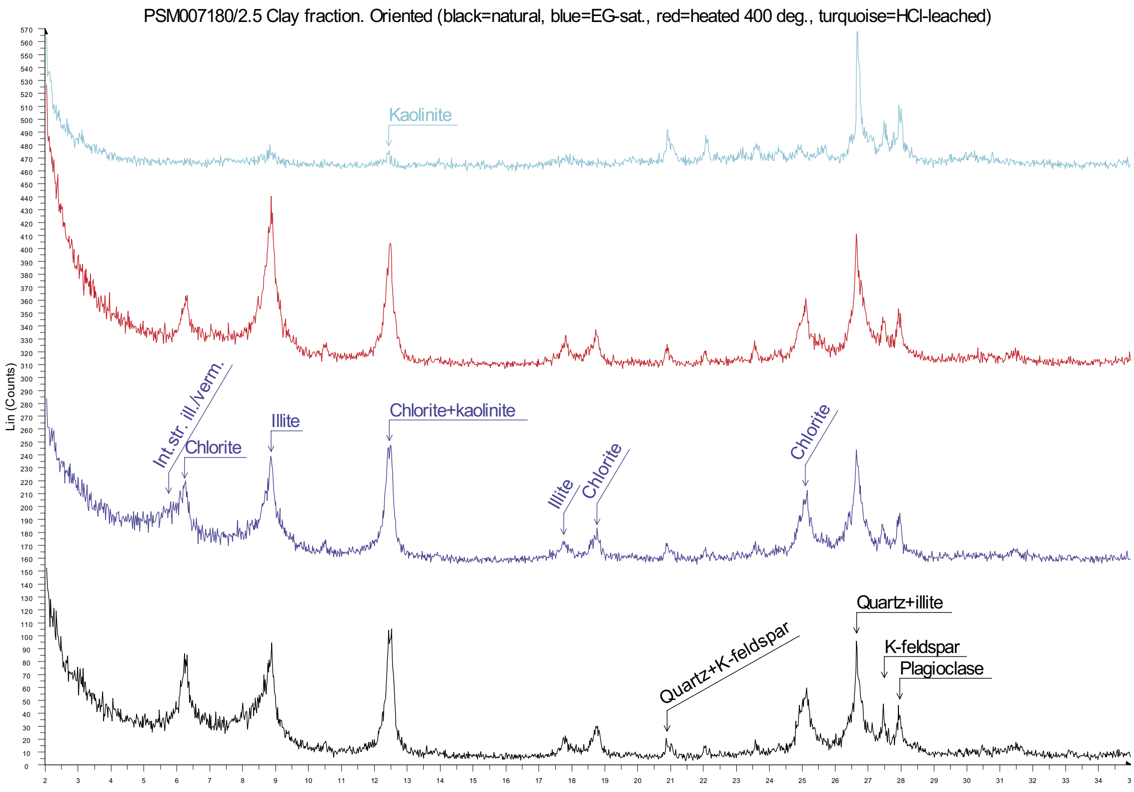


Figure 5-34. *X-ray diffractograms of <2 µm fraction of sample PSM007180/2.5. The analysis was performed with preferred orientation of the crystallites.*

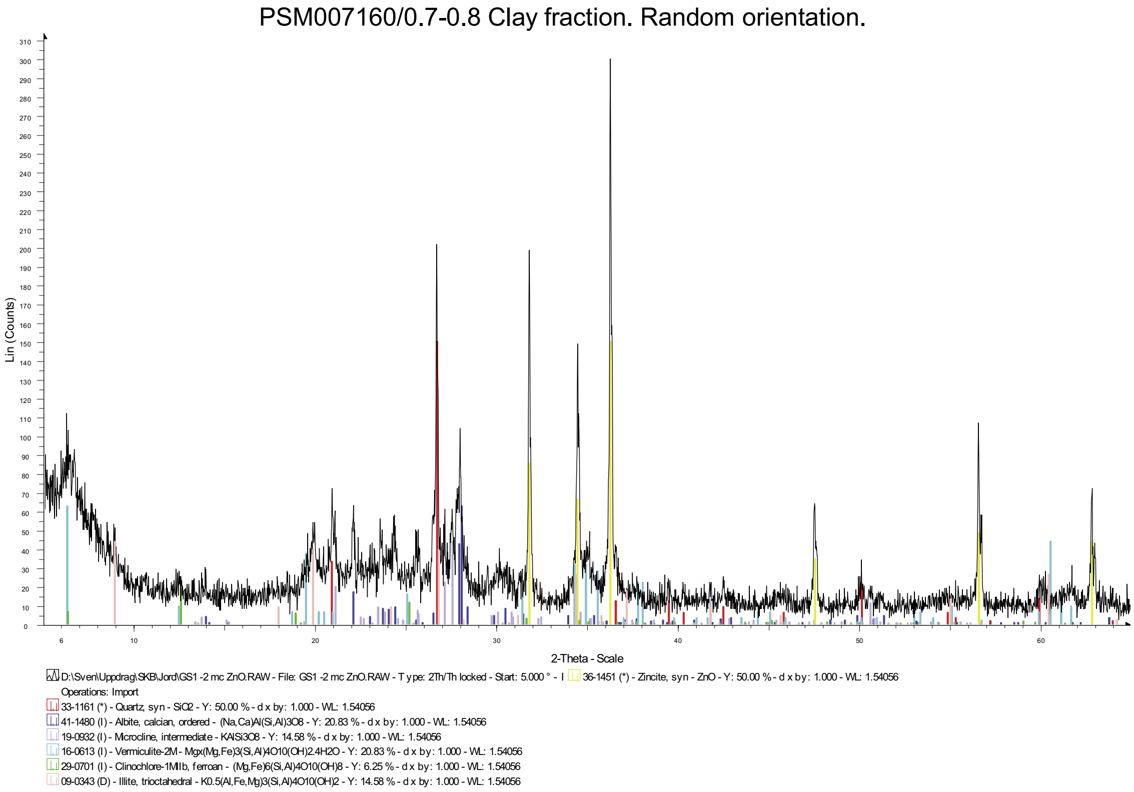


Figure 5-35. *X-ray diffractogram of matrix fraction of sample PSM007160/0.7–0.8. The analysis was performed with random orientation of the crystals.*

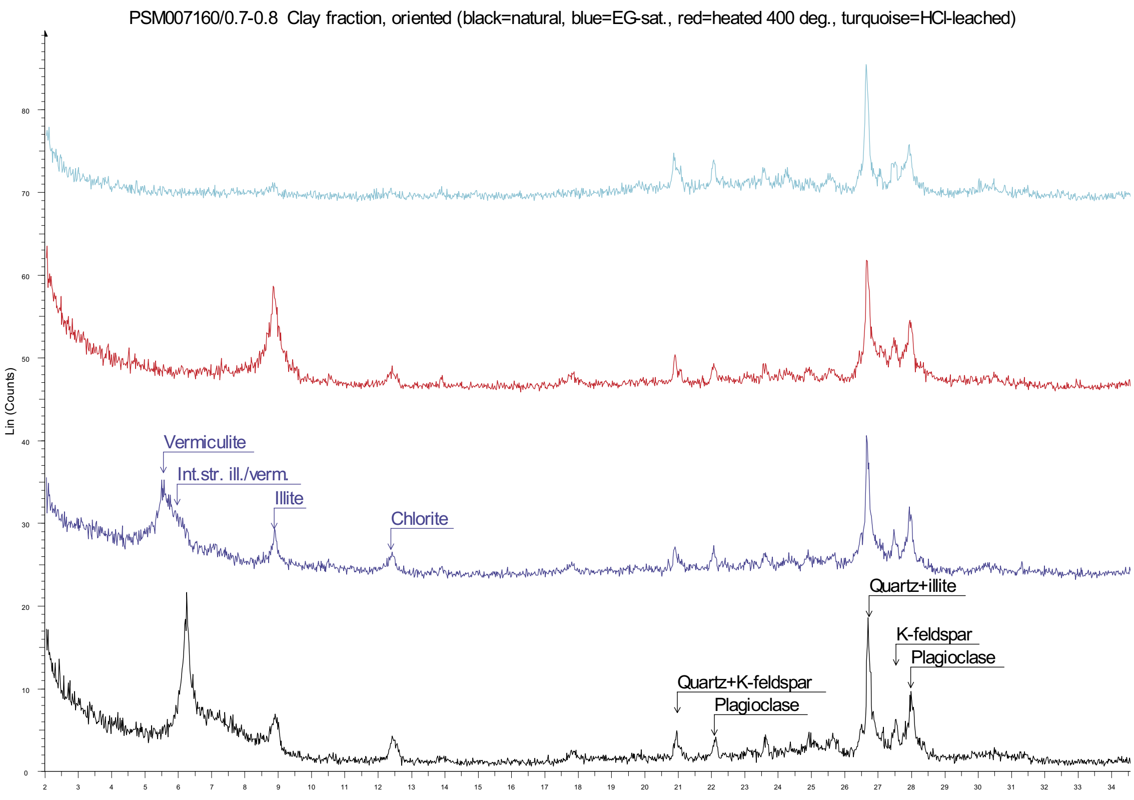


Figure 5-36. *X-ray diffractograms of <2 µm fraction of sample PSM007160/0.7–0.8. The analysis was performed with preferred orientation of the crystallites.*

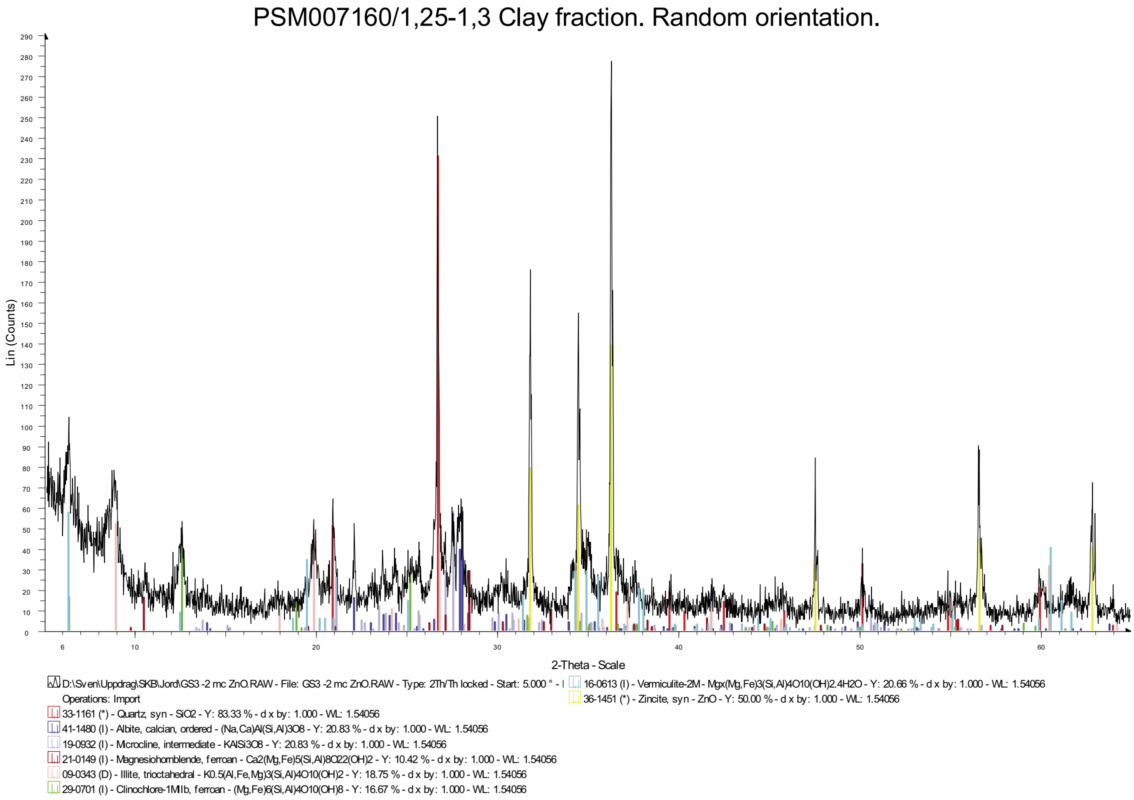


***Figure 5-37.** X-ray diffractogram of matrix fraction of sample PSM007160/1.25–1.3. The analysis was performed with random orientation of the crystals.*

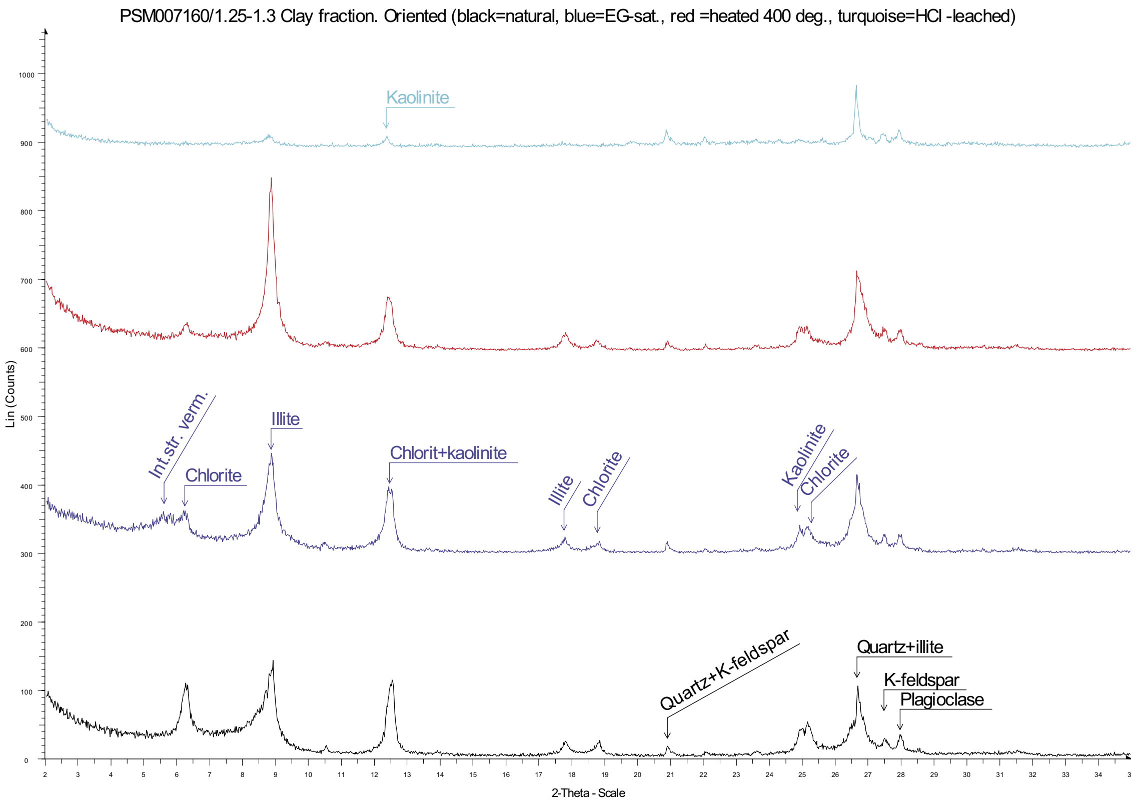


***Figure 5-38.** X-ray diffractograms of <2 µm fraction of sample PSM007160/1.25–1.3. The analysis performed with preferred orientation of the crystallites.*

Clay sample PSM007171/0.5

Clay fraction (grain size fraction < 2 µm)

Peaks from quartz, plagioclase, potassium feldspar and illite are found in the X-ray diffractogram (Figure 5-39). A hump in the diffractogram, from 19° to 28° (2-Theta), indicates large amounts amorphous material in this sample. A lot of shells of diatoms (silica algae) have observed in this clay. Their presence may explain the uncommon X-ray diffraction pattern. The yellow lines show the positions of peaks of the standard (ZnO).

Only weak peaks from the clay minerals; illite, kaolinite, vermiculite and a interstratified mineral, are found in the X-ray diffractograms (Figure 5-40). The interstratified mineral may consist of three components; illite, chlorite and vermiculite. Peaks from quarts and feldspars are also present in the diffractograms.

Clay sample PSM007171/1.8

Clay fraction (grain size fraction < 2 µm)

Quartz, plagioclase, potassium feldspar, hornblende, illite, chlorite and vermiculite were identified (Figure 5-41). The yellow lines show the positions of peaks of the standard (ZnO).

The more diagnostic analysis for the clay minerals displays the presence of illite, chlorite, vermiculite and kaolinite (Figure 5-42). The presence quarts, feldspars and hornblende is also documented.

5.3.6 Results from the quantitative XRD analyses

Two method were applied for determination of mineral content in the samples, quantitative X-ray diffraction analysis by using mineral standards (QXRD) and quantitative Rietveld technique. Results of the determinations are given in Table 5-11.

The Rietveld technique was only applied for the till samples. It was not applicable for the clays because the structure data for illite and vermiculite are not accessible in the database, even less data is available for interstratified minerals. Instead of illite structure muscovite structure was used for calculation of mineral composition of the tills. Their structures are similar but illite has lower potassium content, which are compensated by H_2O^+-ions and the lattice is more disordered in illite. The presence of vermiculite may somewhat influence the calculated content of chlorite because structural similarities between the mineral.

The QXRD method is more applicable for quantitative analysis of minerals in clays. But uncertainty is large especially for the determination of the vermiculite content. In this case the 060-peak at 1.50 Å has been used. At that position (1.50 Å) in the X-ray diffractograms peaks from quartz and chlorite are also present. Corrections for their contributions to the 1.50 Å-peak were made and then vermiculite content was calculated.

The matrix of the till is completely dominated by feldspars and quartz (Table 5-11). It is therefore suggested that the mineralogy of the till reflects that of the local felsic bedrock cf /Nilsson et al. 2004/. However one sample from Profile 3 (PSM007171) contains significant amounts of calcite (Table 5-11), which also was shown by the analyses with Passons apparatus (see above).

Illite is the dominating clay mineral followed by chlorite and kaolinite. That is in accordance with other mineralogical studies of water deposited clays from other parts of Sweden, e.g. Uppland /Snäll 2004/. The results imply that most of the clays only to a small degree have been affected by chemical weathering cf /Snäll 2004/. The presence of vermiculite in the gyttja clay from Profile 1 (PSM007160) indicates, however, chemical alteration of the clay minerals. All till samples contain a significant amount of vermiculite indicating clay mineral alteration by chemical weathering.

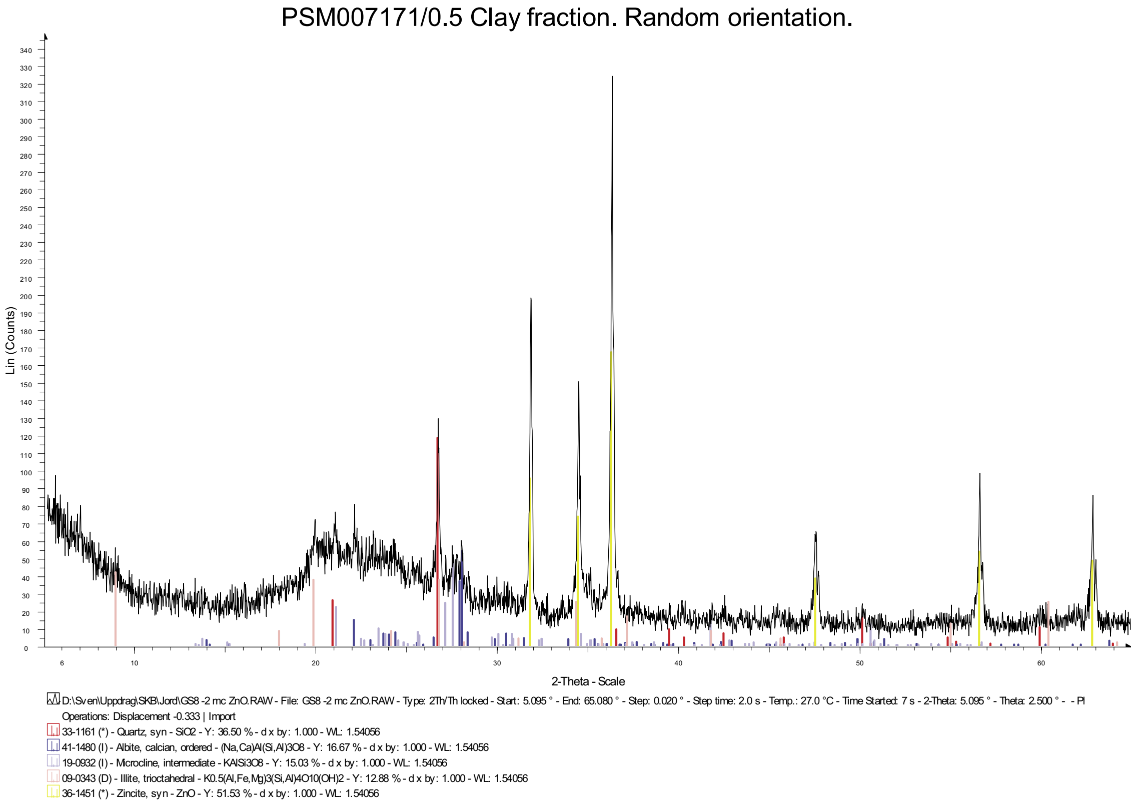


Figure 5-39. *X-ray diffractogram of matrix fraction of sample PSM007171/0.5. The analysis was performed with random orientation of the crystals.*

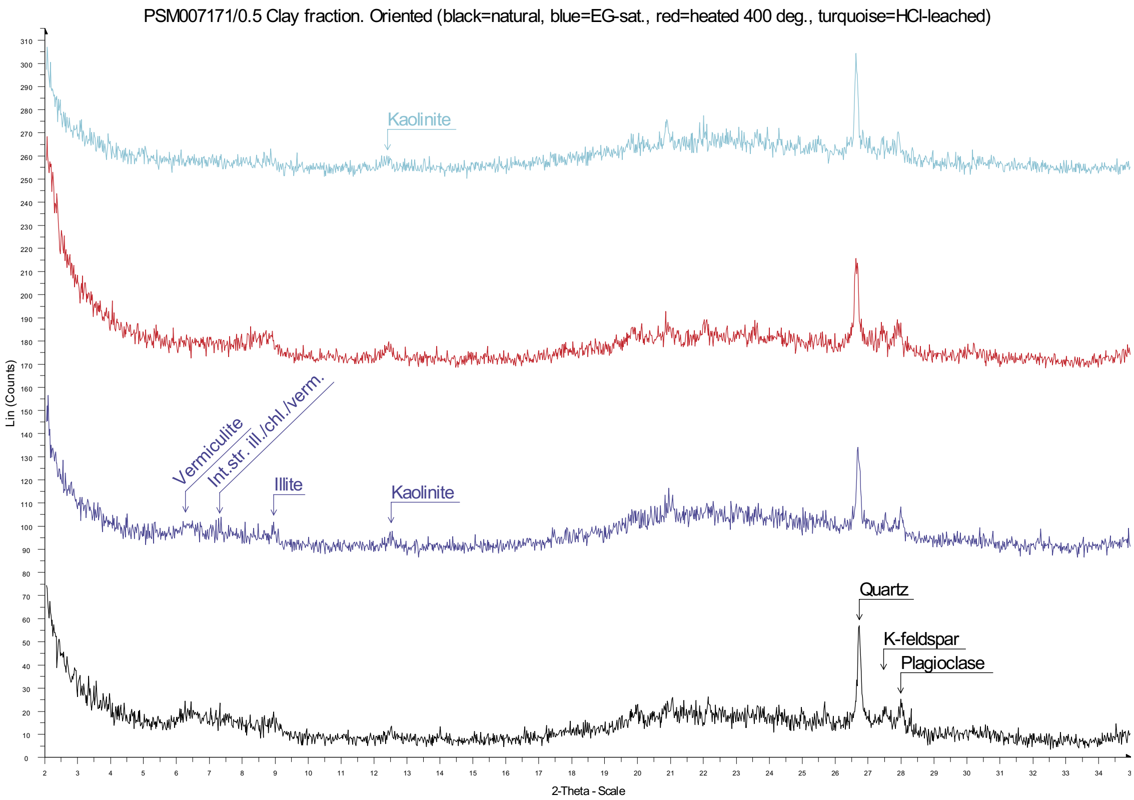


Figure 5-40. *X-ray diffractograms of <2 μm fraction of sample PSM007171/0.5. The analysis was performed with preferred orientation of the crystallites.*

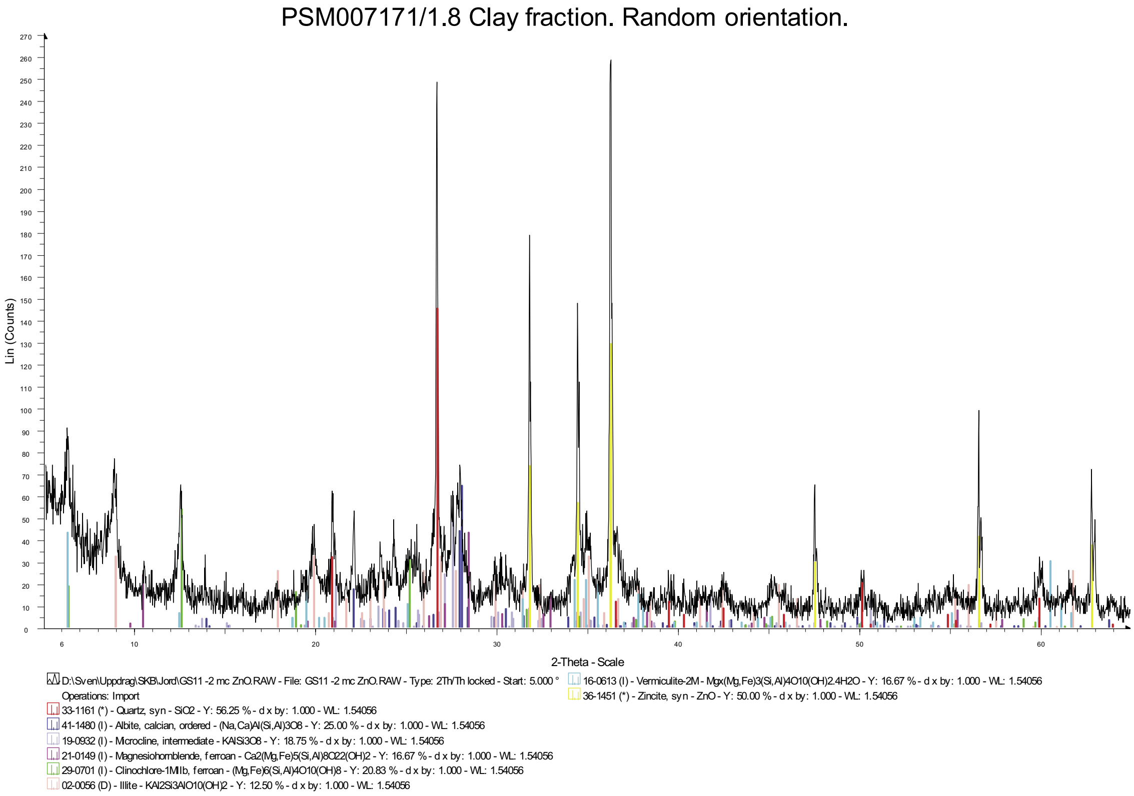


Figure 5-41. *X-ray diffractogram of matrix fraction of sample PSM007171/1.8. The analysis was performed with random orientation of the crystals.*

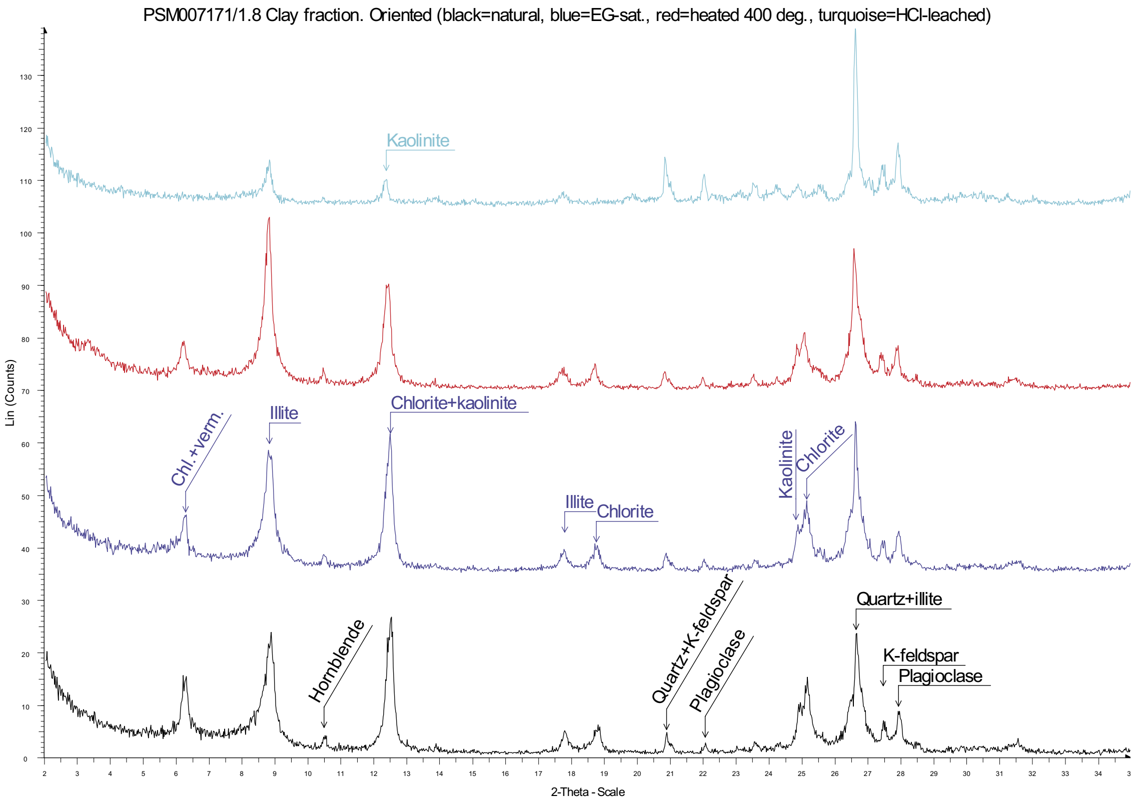


Figure 5-42. *X-ray diffractograms of <2 µm fraction of sample PSM007171/1.8. The analysis was performed with preferred orientation of the crystals.*

Table 5-11. Mineral composition of the matrix fractions (fractions < 2 mm) in the till samples and the clay fractions (fractions < 2 µm) in the clay samples. Two X-ray diffraction methods have been applied for the analyses, quantitative X-ray diffraction analysis on basis of mixtures of standard minerals (QXRD) and quantitative Rietveld technique. K-fsp. = potassium feldspar, Plag. = plagioclase, Hbl. = hornblende, Kaol. = kaolinite and Verm. = vermiculite.

		Quartz		K-fsp		Plag.		Hbl.		Calcite	
		QXRD	Rietv	QXRD	Rietv	QXRD	Rietv	QXRD	Rietv	QXRD	Rietv
		%	%	%	%	%	%	%	%	%	%
	Tills										
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		
	Clays										
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			

		Illite		Chlorite		Kaol.		Verm.	
		QXRD	Rietv.	QXRD	Rietv.	QXRD	Rietv.	QXRD	Rietv.
		%	%	%	%	%	%	%	%
	Tills								
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	
	Clays								
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	

5.3.7 Chemical composition of the Quaternary deposits

The results from the chemical analyses of Quaternary deposits are shown in Appendix 8. The average chemical composition of the six analysed till samples are shown in (Table 5-12).

A comparison wit SGU's national database /SGU 2006/ shows that the chemical composition of the till in the Simpevarp area is relatively normal in a Swedish context (Table 5-13). The chemical composition of the till probably reflects that of the local bedrock /Nilsson et al. 2004/.

The chemical composition of the water laid sediments may reflect the environmental conditions prevailing during the time of sediment accumulation The highest SiO_2 content was recorded in the gyttja clay from Profile 3 (see PSM007171, Appendix 8). That is due to a high concentration of siliceous microfossils (e.g. diatoms), which has been verified by studies in microscope.

The high S content in the gyttja at Profile 5 (see PSM007190, Appendix 8) probably reflect the presence of sulphidic minerals formed in an anoxic environment. Such minerals are common in fine-grained sediments containing organic material. The contents of Cd, Mo and Cu are relatively high in the gyttja at Profile 5. That may be an effect of anoxic bottom conditions during sediment accumulation cf /Sternbeck et al. 2000/. 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.

Table 5-12. Analyses of six till samples from the Simpevarp regional model area. 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.

	Element	Unit	N	Mean	Std.dev	Max	Min
Al_2O_3	Aluminium	%	6	14.1	0.66	14.6	12.9
BaO	Barium	%	6	0.107	0.01	0.123	0.094
CaO	Calcium	%	6	2.02	0.58	2.77	1.13
Fe_2O_3	Iron	%	6	3.98	0.76	5.00	3.22
K_2O	Potassium	%	6	4.19	0.53	5.00	3.65
MgO	Magnesium	%	6	1.41	0.51	2.31	1.02
MnO	Manganese	%	6	0.061	0.008	0.071	0.050
Na_2O	Sodium	%	6	3.55	0.22	3.77	3.27
P_2O_5	Phosphorus	%	6	0.181	0.053	0.287	0.137
SiO_2	Silicon (calculated)	%	6	69.2	2.34	71.6	65.2
TiO_2	Titanium	%	6	0.485	0.117	0.707	0.365
As	Arsenic	ppm	6	0.90	0.19	1.17	0.71
Ba	Barium	ppm	6	958	89	1100	840
Be	Beryllium	ppm	6	1.57	1.10	3.12	0.67
Br	Boron	ppm	6	0.91	0.36	1.54	0.64
Cd	Cadmium	ppm	6	0.027	0.008	0.040	0.018
Ce	Cerium	ppm	6	58.5	13.0	78.8	41.6
Cl	Chlorine	ppm	6	60.5	10.3	77.8	51.1
Co	Cobalt	ppm	6	6.94	2.46	11.80	3.46
Cs	Caesium	ppm	6	1.98	1.03	3.46	0.56
Cr	Chromium	ppm	6	40.8	11.1	58.2	28.3
Cu	Copper	ppm	6	11.5	3.8	18.1	8.3
Dy	Dysprosium	ppm	6	2.18	0.59	3.09	1.64
Er	Erbium	ppm	6	1.23	0.21	1.50	0.99
Eu	Europium	ppm	6	0.65	0.20	0.95	0.42
Ga	Gallium	ppm	6	12.3	1.6	14.9	10.7
Gd	Gadolinium	ppm	6	2.12	0.51	2.86	1.42
Hf	Hafnium	ppm	6	4.37	0.87	5.42	3.34
Ho	Holmium	ppm	6	0.47	0.12	0.66	0.36
La	Lanthanum	ppm	6	28.6	6.6	39.0	20.1
Li	Lithium	ppm	6	23.7	7.1	35.2	16.1
Lu	Lutetium	ppm	6	0.22	0.05	0.31	0.17
Mo	Molybdenum	ppm	6	0.89	0.12	1.08	0.76
Nb	Niobium	ppm	6	9.05	1.40	10.7	7.05
Nd	Neodymium	ppm	6	27.7	6.79	38.8	20.1
Ni	Nickel	ppm	6	11.3	2.75	15.7	8.1
Pb	Lead	ppm	6	7.58	0.74	8.35	6.71
Pr	Praseodymium	ppm	6	6.61	1.76	9.60	4.72
Rb	Rubidium	ppm	6	110	13.9	129	93.8
S	Sulphur	ppm	6	157	157	409	34.7
Sc	Scandium	ppm	6	5.85	1.47	8.73	4.56
Sm	Samarium	ppm	6	3.89	0.86	4.81	2.73
Sn	Tin	ppm	6	1.01	0.19	1.35	0.83

	Element	Unit	N	Mean	Std.dev	Max	Min
Sr	Strontium	ppm	6	464	86	554	354
Ta	Tantalum	ppm	6	0.81	0.15	0.99	0.62
Tb	Terbium	ppm	6	0.46	0.13	0.71	0.36
Th	Thorium	ppm	6	11.5	3.23	17.3	8.53
Tl	Thallium	ppm	6	0.181	0.085	0.286	0.062
Tm	Thulium	ppm	6	0.20	0.06	0.30	0.13
U	Uranium	ppm	6	2.75	1.18	5.03	1.94
V	Vanadium	ppm	6	49.4	14.5	73.9	33.7
W	Tungsten	ppm	6	1.80	0.88	3.28	1.05
Y	Yttrium	ppm	6	17.2	2.95	21.0	14.1
Yb	Ytterbium	ppm	6	1.47	0.29	1.93	1.17
Zn	Zinc	ppm	6	56.1	13.6	76.4	44.1
Zr	Zirconium	ppm	6	192	37.9	254	152

Table 5-13. Element analyses on till samples from the Simpevarp area and from the national geochemical survey conducted by SGU /SGU 2006/. The samples were analysed with the XRF technique.

			Till – Swedish reference (XRF)				
	Element	**Unit**	**N**	**Mean**	**St dev**	**Max**	**Min**
Al_2O_3	Aluminium	%	26343	13.59	1.75	33.1	1.3
BaO	Barium	%	26343	0.061	0.01	0.85	0.02
CaO	Calcium	%	26343	2.26	1.65	54.98	0.09
Fe_2O_3	Iron	%	26343	3.86	1.25	15.3	0.49
K_2O	Potassium	%	26343	2.88	0.47	6.7	0.37
MgO	Magnesium	%	26343	1.38	0.58	7.89	0.15
MnO	Manganese	%	26343	0.063	0.030	1.124	0.009
Na_2O	Sodium	%	26343	2.68	0.71	5.23	0.09
P_2O_5	Phosphorus	%	26343	0.233	0.081	1.97	0.01
SiO_2	Silicon (calculated)	%	26343	72.1	3.8	89.2	41.1
TiO_2	Titanium	%	26343	0.739	0.181	2.596	0.069

The gyttja and gyttja clay were probably deposited in the shallow bays and the high organic content and the high content of siliceous microfossils (PSM007171) are probably the effect of a high primary productivity caused by high water concentrations of nutrients. The accumulation of organic material caused by oxygen depletion as an effect of the bacterial oxidation of organic matter.

5.3.8 Soil chemistry

pH

The overall pattern for pH in the soil profiles of the trenches showed comparably low values between 4.5 and 6 in the upper soil layers with higher values in deeper layers reaching around 7 or higher in depths below 2 m (Figure 5-43). The values in the upper layer coincided fairly well with the values found in the site inventory in 2004 /Lundin et al. 2005b/.

Great similarities were noticed for trench 1 and 4 with pH in the upper soil layers were 5–6, increasing with depth to slightly below 7 at 2.5 to 3 m depth. In profiles PSM-00007160 (trench 1) and PSM-007180 (trench 4), pH values showed very much the same stratification. The other profiles in these trenches deviated slightly. In trench 3, there was a strong stratification towards depth from about pH 4.5 in the humus layer and 4.7 in the top mineral soil layer to about pH 8 in a depth of c 3 m (Figure 5-43). In trench 5, the pattern was different to the other trenches with a fairly stable pH between 5.6 and 5.2, actually decreasing, in the upper metre of the profile. At this depth there was a considerable increase to about 6.5 with a consecutive further increase to about pH 7 below 2 m depth (Figure 5-43 and Appendix 9ab).

Organic carbon

Carbon contents in the profiles showed similar patterns for the four trenches with relatively high values in the upper soil layers, mainly between 0.7% and 5% in the mineral soil, decreasing with depth to low values (< 0.2%) below one metre depth (Figure 5-44). Profile PSM-007190, trench 5, deviated from this as having carbon contents around 18% in the upper 1.5 m indicating a histic horizon. In the deeper layers in trench 5, the carbon content was on similar values as for the other three trenches.

Similarities between carbon content stratification for the profiles inside each trench were good with only slight deviations in the very upper soil layers (Figure 5-44 and Appendix 9ab). In relation to the site investigation in 2004, the values in the upper mineral soil layers were lower in the trenches compared to the inventory pits /Lundin et al. 2005b/.

Nitrogen

The nitrogen content in the organic layers agreed fairly well with the earlier soil investigation /Lundin et al. 2005b/ with values between 0.9% and 1.9%. Stratification with soil profile depth followed the pattern of carbon with higher values in the upper mineral soil layers where contents were 0.02 up to 0.5% and decreasing with depth to values on less then 0.1% below one metre depth. The nitrogen content in the upper half metre of the mineral soil coincided with values from the site inventory and the general pattern of this Swedish region /Lundin et al. 2005b/. In the deepest layers values were on 0.01–0.02% (Figure 5-45 and Appendix 9ab).

Trench 5 was deviating from the other three trenches having comparably high nitrogen contents to one and a half metre depth being1.2 to 1.8%. This was probably furnished by organic nitrogen in the peat and gyttja material in this profile. Below 1.5 m depth there was a considerable decrease to similar contents as for the other profiles, i.e. on c 0.1% (Figure 5-45 and Appendix 9ab).

Base cations

Exchangeable contents of Na, K, Ca, Mg and Mn were determined in ammonia-acetate and *Aqua Regia*. The distribution pattern of stratigraphy in the profiles were, in one way, rather similar with low concentrations in the uppermost mineral soil layers, increasing with depth but again to be lower in some cases in the very deepest layers. Similarities between elements in one profile were greater than the stratification in the four profiles. The profile in trench 1 mainly showed higher values in the top and deep layers with lower concentrations in depth of 1–2 m. Trench 3 showed the opposite pattern with high values in the middle of the profile and lower on top and in the deep soil layers. In trench 4, the stratification from low values in the top soil to higher with depth was rather pronounced while trench 5 was influenced by the upper metre peaty soil with the shell layer being obvious in the one metre level, especially for Ca and Na (Figure 5-46, Figure 5-47, Figure 5-48, Figure 5-49 and Appendix 10a and b).

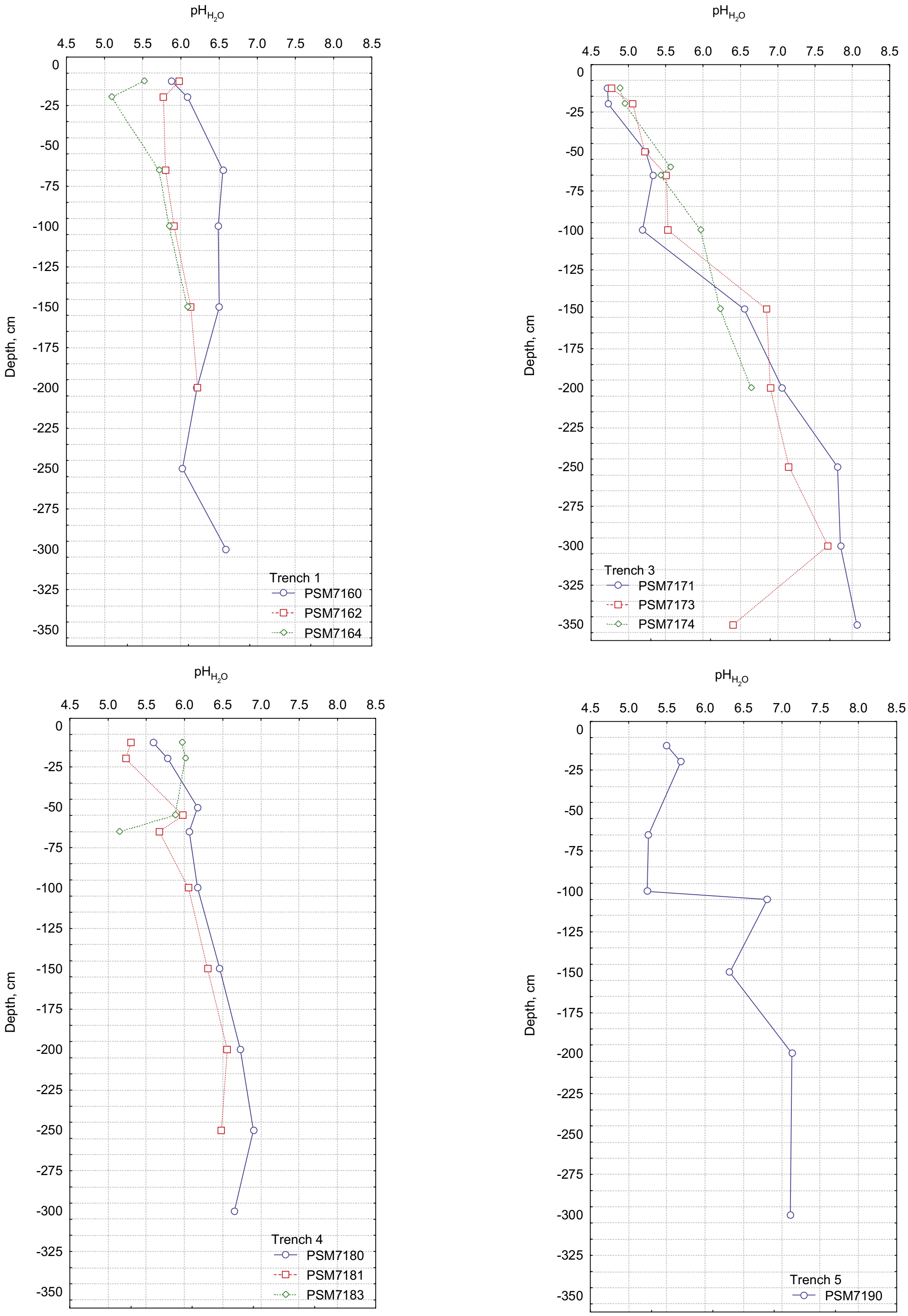


Figure 5-43. *Profiles of pH values in the Oskarshamn area trenches 1, 3, 4 and 5.*

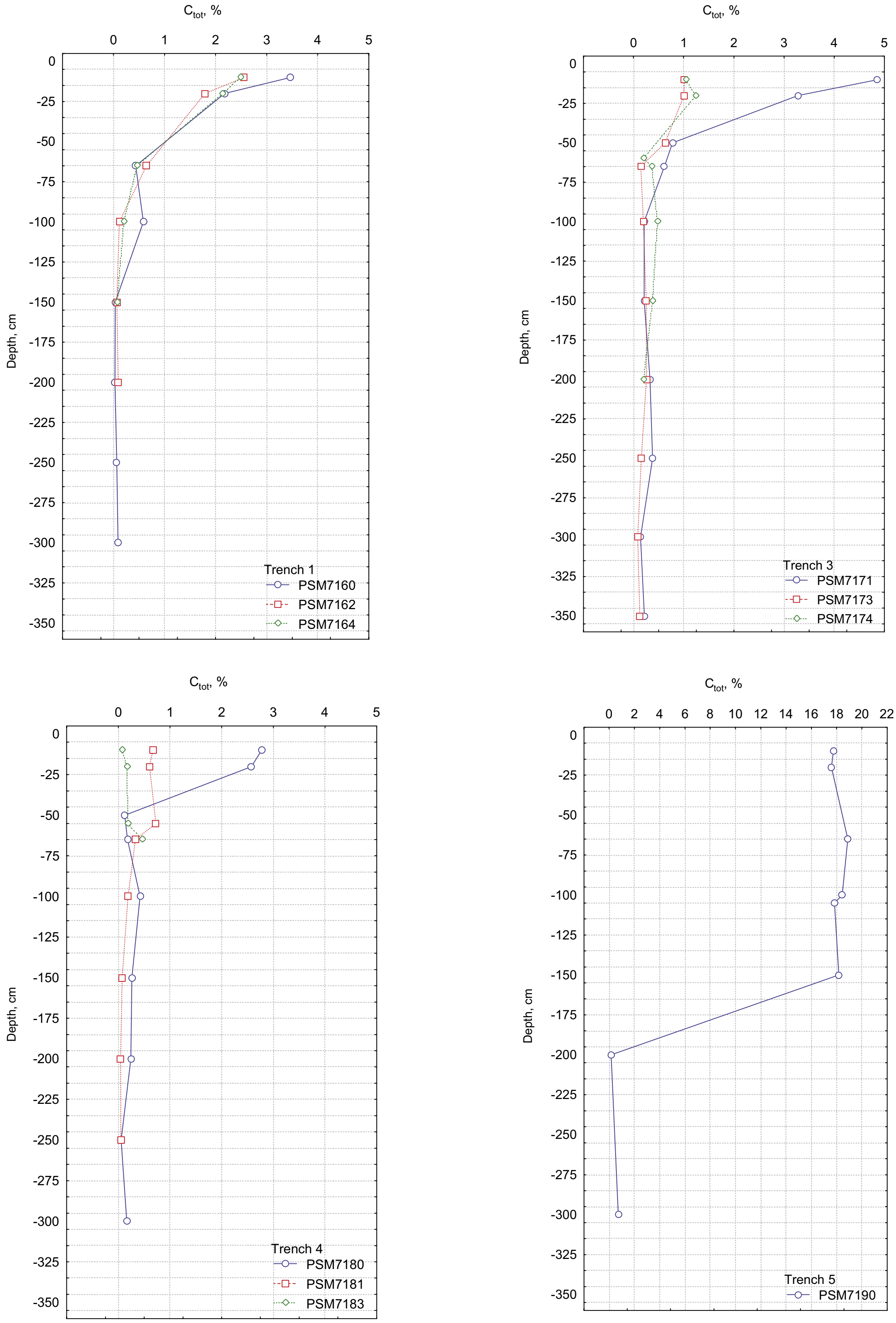


***Figure 5-44.** Carbon concentration stratification with soil depth in the profiles of the four trenches in Oskarshamn area 2005.*

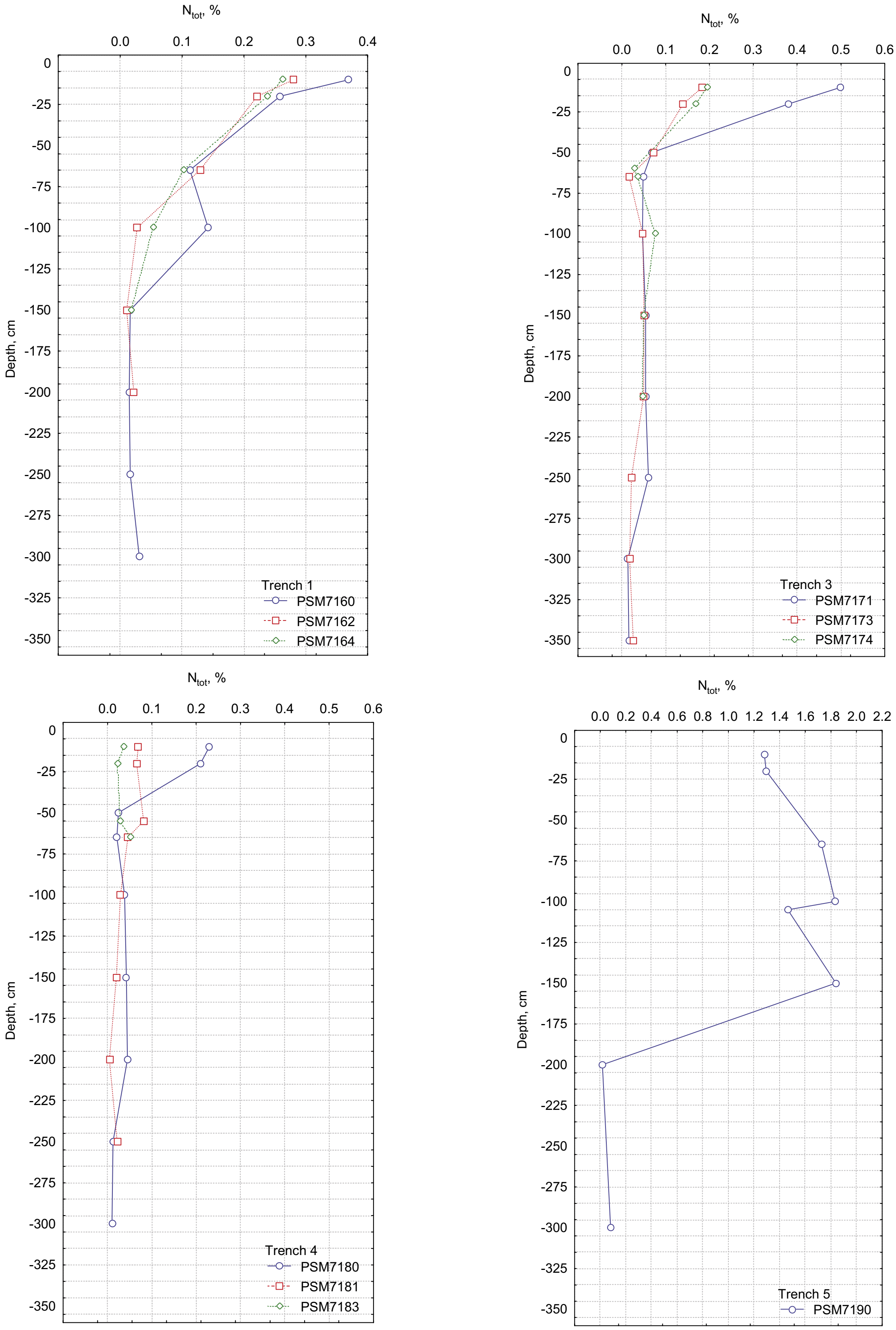


Figure 5-45. *Nitrogen concentration stratifications with soil depth in the profiles of the four trenches of the Oskarshamn area, 2005.*

Sodium, Na

Sodium is to a large extent influenced from Na-rich bedrock and sea salts. In the profiles, the NH_4Ac extractable concentrations varied between 0.01 and 0.08 g/kg with the special exception for the one metre depth in trench 5 where Na reached the highest value on 0.13 g/kg (Figure 5-46). In trench 1, the Na_{NH4Ac} content reached 0.06 g/kg in layers 0.5 to 1 m depth and being lower above and below. The $Na_{\mathit{Aqua\ Regia}}$ showed similar pattern but with values on slightly above 0.2 g/kg in the high layers and c 0.05 g/kg in deeper layers. The share of Na_{NH4Ac} compared to $Na_{\mathit{Aqua\ Regia}}$ was 10–30%. In trench 3, Na reached high values in depths between one and three metres and the pattern was similar for both extracts. A similar stratification but not as pronounced could be seen for trench 4 and also in trench 5 where the shell layer furnished an extra strong peak.

Potassium, K

Potassium is an important nutrient for the biological system and circulates to a large extent between the upper soil and plants. It originates to a large extent from the clay minerals. For K four extractions were made and mainly NH4Ac and ammonium lactate gave the same values for easily accessible K while potentially accessible K used HCl and Aqua Regia, respectively for two extractions, also giving similar results but on higher levels as compared to the ammonia extractions. The share of easily accessible K to the potential accessible was about 4–6%. In trench 1, K increased from the ground surface to one metre depth with a decrease to further depths. Values in the upper layers were c 0.02–0.03 g/kg for K_{NH4Ac} and 2–3g/kg for $K_{\mathit{Aqua\ Regia}}$ (Figure 5-47). In deep layers the values were c 0.04 g/kg and c 0.8 g/kg, respectively.

In trench 3 the higher values in layers 1–3 m reached 0.3–0.4 g/kg for K_{NH4Ac} and 4–5 g/kg for $K_{\mathit{Aqua\ Regia}}$. In upper and deeper layers similar values as for trench 1 occurred. In trench 4, K contents increased from low values in the upper layers to high in 2–2.5 m depth, i.e. 1–5 g/kg for $K_{\mathit{Aqua\ Regia}}$ but with K_{NH4Ac} only on 0.02 g/kg, ratio only 5%. In trench 5, rather low values for $K_{\mathit{Aqua\ Regia}}$ occurred (c 1 g/kg) and the relation to K_{NH4Ac} was fairly similar with 10–30% throughout the total profile, with higher ratios in the very top and bottom layers (Figure 5-47).

Calcium, Ca

Calcium is one important macro-nutrient originating from the mineral soil. Contents in the Oskarshamn area trenches were on comparably high levels as compared to ordinary forest soils. In the upper mineral soil layers, the content range was 0.06–5 g/kg. Contents in ordinary Swedish forest soils with Podzol profile could be 0.08 g/kg and in the south-east Swedish region c 0.2 g/kg. The general pattern for the three trenches 1, 3 and 4 is increasing contents with depth from 0.1 to 1 g Ca_{NH4Ac}/kg to 1–3 g Ca_{NH4Ac}/kg in the deep layers and corresponding $Ca_{\mathit{Aqua\ Regia}}$ values were 0.1–2 g/kg in the upper layers and 3–8 g/kg in the deep layers. This gave ratios $Ca_{NH4Ac}/Ca_{\mathit{Aqua\ Regia}}$ of 20–50% in the mineral soil below0.5–1.5 m depth. In the upper layers ratios were generally higher (Figure 5-48 and Appendix 10a). This could be compared with the concentration in deep layers at the trench sites of the Forsmark area where Ca_{NH4Ac} values on c 2 g/kg were common.

Deviations from the general pattern were found in trench 1 where high values of especially Ca_{NH4Ac} on 2–3 g/kg was found and also being almost the same as for $Ca_{\mathit{Aqua\ Regia}}$. In trench 5, even larger deviations from the pattern occurred with similar contents of Ca_{NH4Ac} and $Ca_{\mathit{Aqua\ Regia}}$ throughout the profile except for the shell layer on about one metre depth. There $Ca_{\mathit{Aqua\ Regia}}$ reached a very high value on over 60 g/kg.

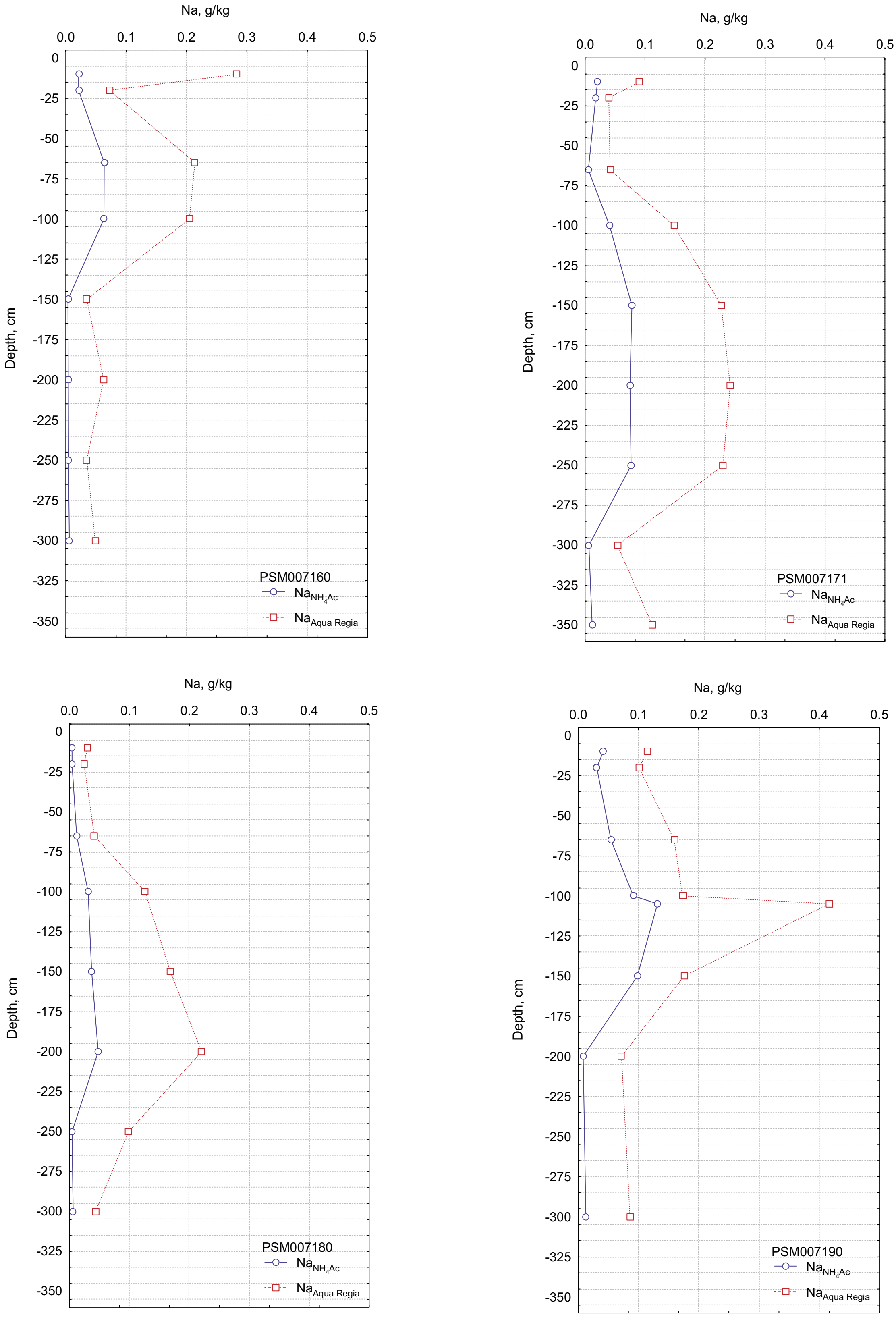


Figure 5-46. *Sodium content stratification with soil depth in the profiles of the four trenches in the Oskarshamn area 2005.*

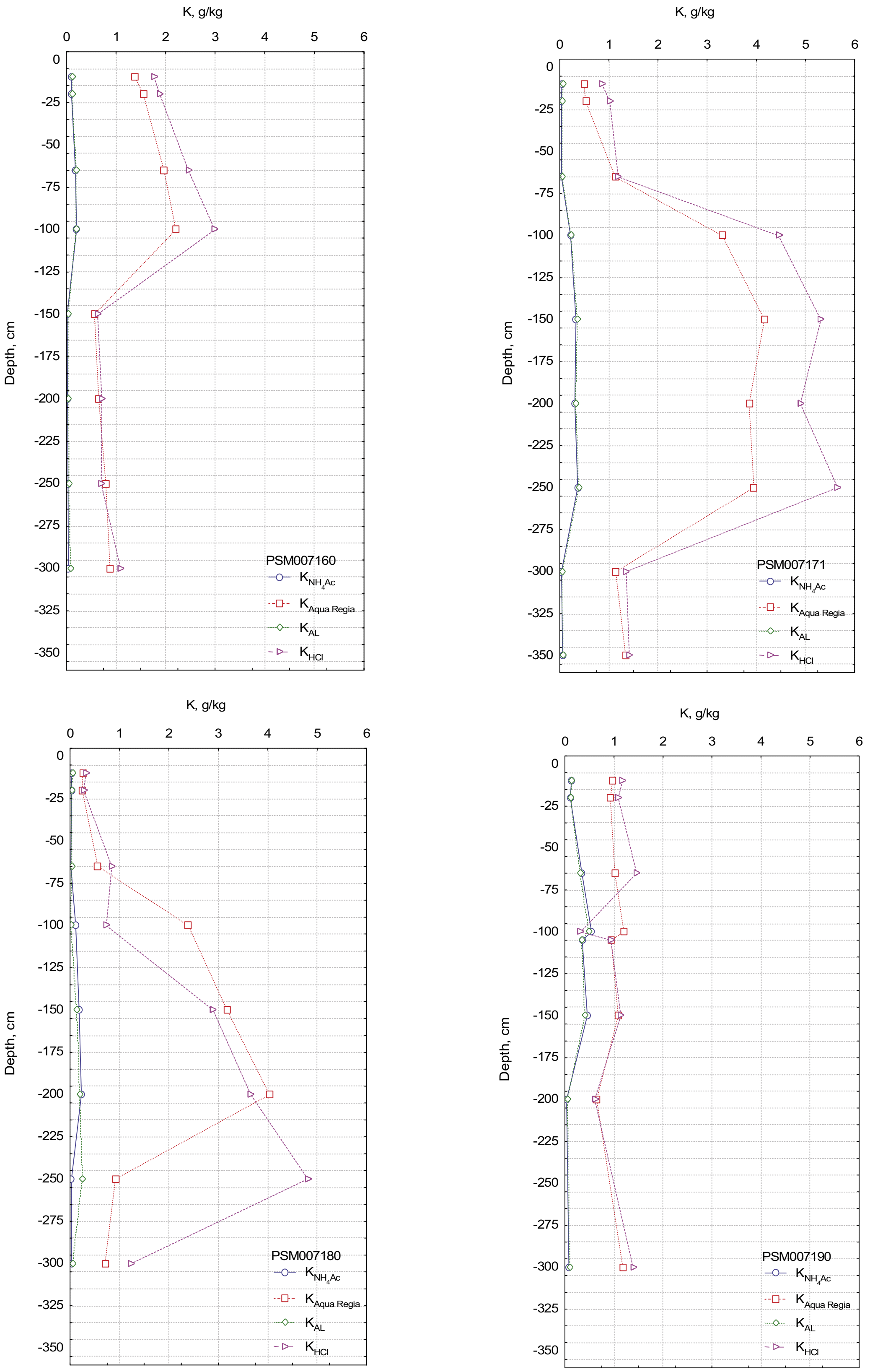


Figure 5-47. *Potassium content stratification with soil depth in the profiles of the four trenches in the Oskarshamn area 2005. Four extractions; NH_4Ac, AL, HCl and Aqua Regia.*

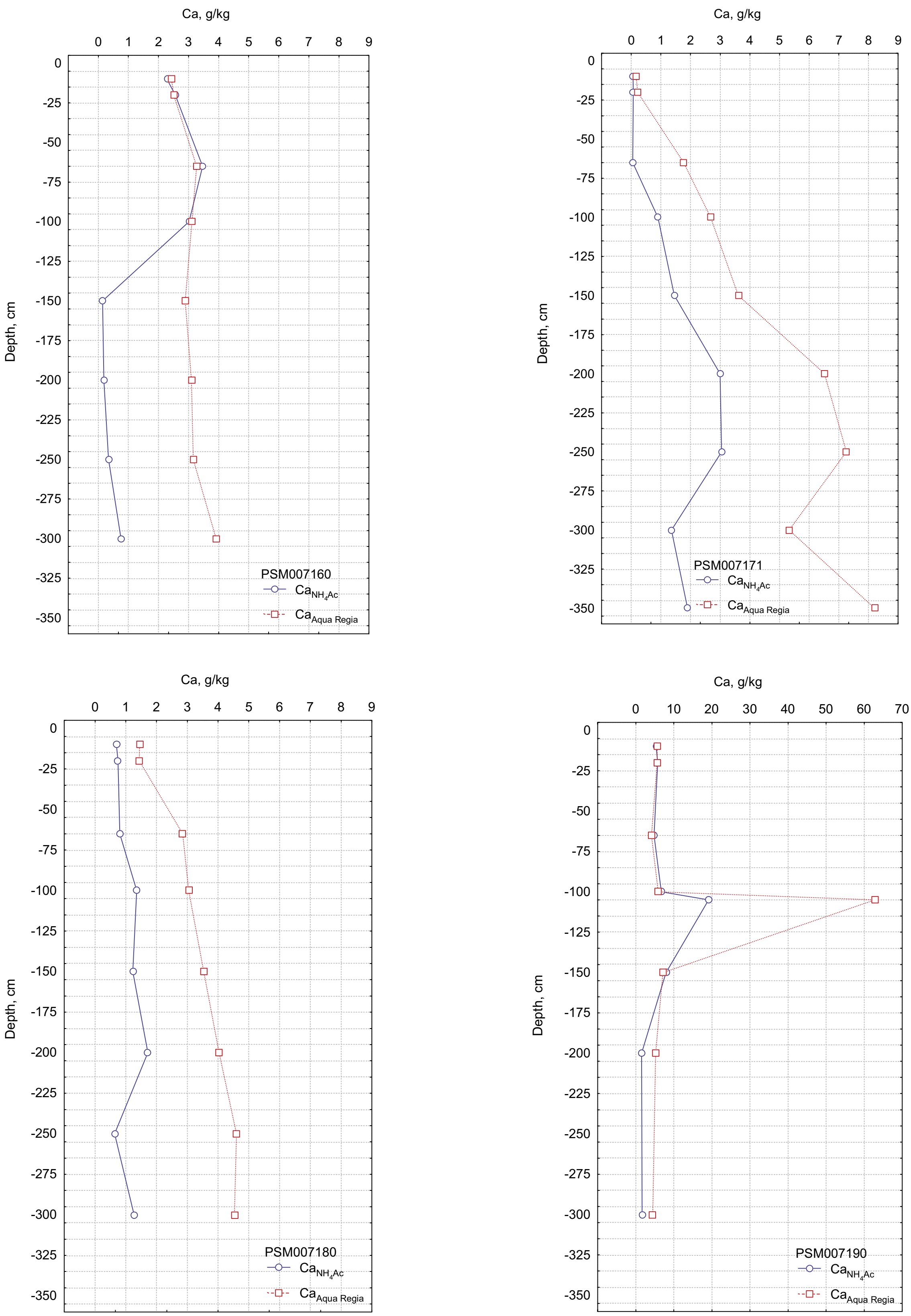


Figure 5-48. *Calcium content stratification with soil depth in the profiles of the four trenches in the Oskarshamn area 2005. Two extractions; NH_4Ac, and Aqua Regia.*

Magnesium, Mg

Magnesium is one important macro-nutrient originating from the mineral soil. Contents of Mg_{NH4Ac} in the Oskarshamn area trenches upper mineral soil horizons were on comparably ordinary levels as compared to the main Swedish forest soils with values on 0.01–0.02 g/kg. In Cambisols values on 0.01–0.2 g/kg could be found. Values in trench 3 and 4 were lower compared to trenches 1 and 5. In general, contents were relatively low in the very top soil layers and the deepest layers with values on 0.01–0.07 g/kg. In the layers inbetween, i.e. 1–2 m depth, higher contents occurred being 0.4–1 g/kg.

Corresponding $Mg_{\textit{Aqua Regia}}$ showed ratios of 0.05 to 0.2 in most layers but especially in the deepest layers the ratio was very low, even below 0.01. Trenches 3 and 4 furnished similar patterns with high $Mg_{\textit{Aqua Regia}}$ below 0.5 m depth while trench 1 had relatively low contents in layers 1.5 m to 2 m and comparably higher above and below. In trench 5, the stratification with depth was smaller and $Mg_{NH4Ac}/Mg_{\textit{Aqua Regia}}$ slightly higher with 0.3 except in depth below 2 m where the ratio was as low as in the other profiles, i.e. c 0.01 (Figure 5-49 and Appendix 10a).

Manganese, Mn

Manganese originates from the mineral soil and forms a number of complexes in the soil horizons. It is taken up by plants and partly circulated in similar way as for potassium, meaning a large return from trees by litter-fall. It is also forming complexes with Ca and then being more difficult to be accessible for plant uptake. Generally, fairly low amounts are easily extractable especially in mineral soil with low organic content. In the trenches of Oskarshamn area stratification patterns deviate between the profiles. Trench 3 and 4 furnishes similarities with fairly low contents in the top soil layers with low Mn_{NH4Ac} (c 1mg/Kg) and being low mainly throughout the profile but with higher values (10 mg/kg) below one metre depth in trench 3. Also trench 1 shows low Mn_{NH4Ac}. In trench 5, the content is larger probably related to the high organic content there, with values on 10–40 mg/kg (Figure 5-50 and Appendix 10a).

The chemically bound Mn, e.g. in oxides, ($Mn_{dit.citr.}$) furnish stratification patterns mainly resembling the $Mn_{\textit{Aqua Regia}}$ stratification but on a lower content level. Fairly similar values are found in the top soil, being low and ratios high, but in deeper layers $Mn_{\textit{Aqua Regia}}$ reaches higher values 100–300 mg/kg and the ratio $Mn_{dit.citr.}/Mn_{\textit{Aqua Regia}}$ being 0.2–0.3. Trench 3 and 4 show similar patterns as for Ca and Mg while trench 1 gives the opposite stratification with fairly high values 200–300 mg/kg) in the top soil layers and below two metres but lower in-between (100-150 mg/kg). Trench 5 furnishes a fairly even stratification for the three extractions with Mn_{NH4Ac} being on c 10 g/kg, $Mn_{dit.citr}$ being c 50 and $Mn_{\textit{Aqua Regia}}$ 5–20 mg/kg (Figure 5-50 and Appenix 9a).

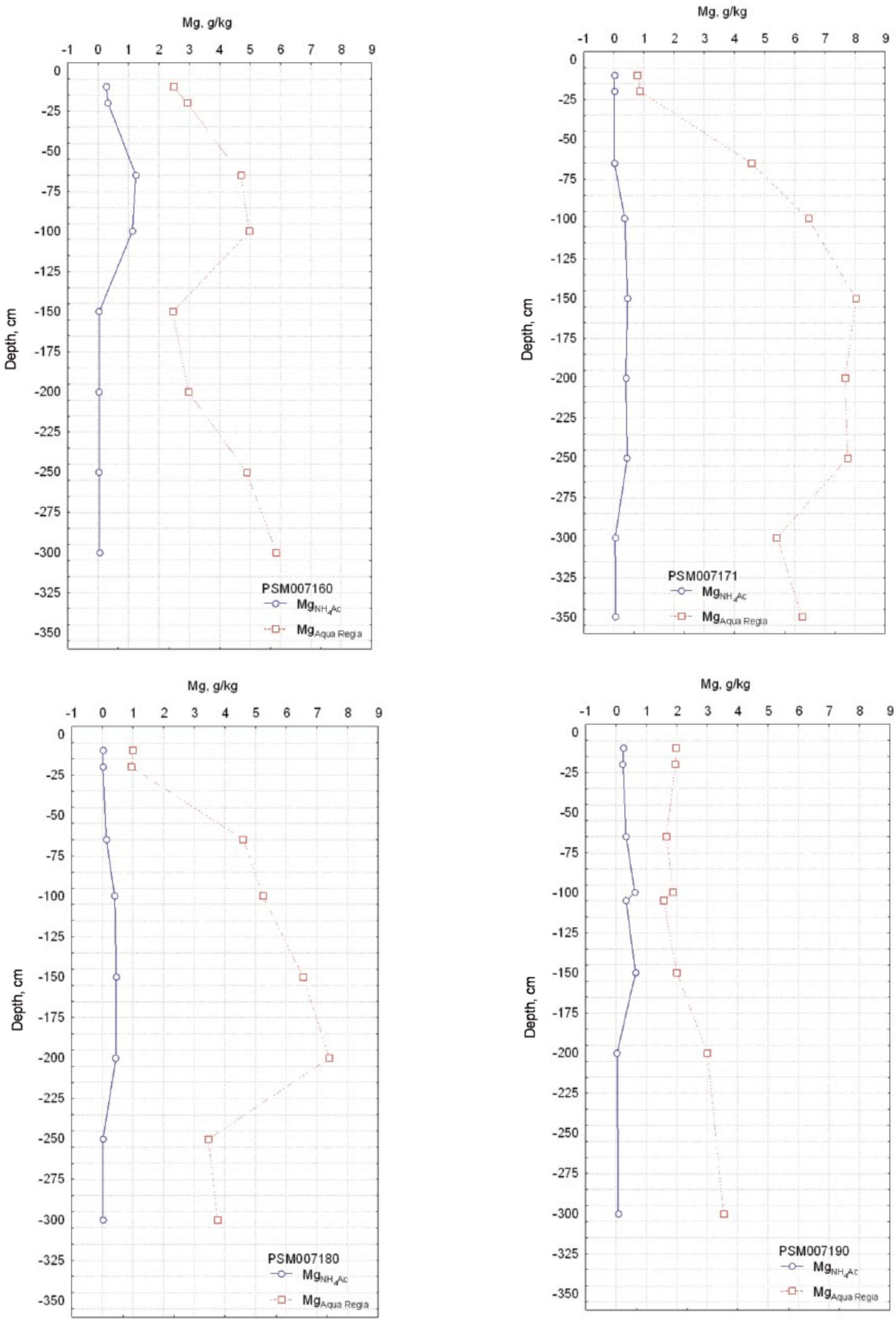


Figure 5-49. *Magnesium content stratification with soil depth in the profiles of the four trenches in the Oskarshamn area 2005. Two extractions; NH_4Ac, and Aqua Regia.*

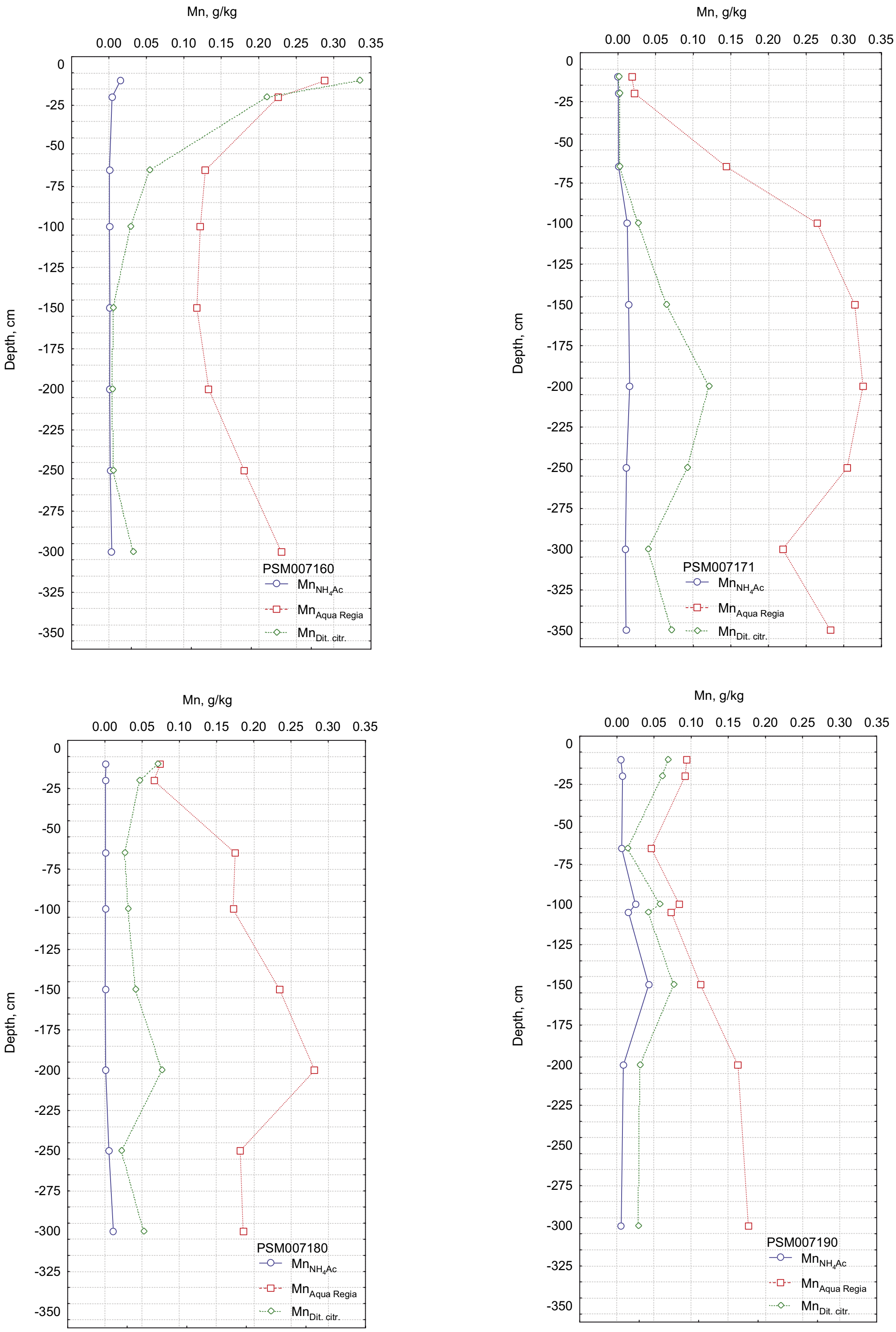


Figure 5-50. *Manganese content stratification with soil depth in the profiles of the four trenches in the Oskarshamn area 2005. Two extractions; NH_4Ac, and Aqua Regia.*

Cation exchange capacity, CEC

The cation exchange capacity relates to the ability of the soil to store cations in exchange places on the surface of soil particles. Organic material and clay furnishes good possibilities for this storage. Also the mineralogy influences CEC. Coarse textured material often has low capacities. In the Oskarshamn area trench profiles organic content were high for the trench 5 and upper part of trench 1. CEC in these profiles also showed fairly high values with in trench 5, 40–60 $mmol_c$/100g down to depth of 1.5 m. Below this CEC was lower about 9 $mmol_c$/100g being anyhow fairly high and there influenced from the clay content. In trench 1, rather high CEC, 20–30 $mmol_c$/100g was found down to one metre depth where carbon content became low and consequently CEC was down on 1–2 $mmol_c$/100g but again being somewhat higher in the deepest more clay-rich layers of 2–3 m (Figure 5-51 and Appendix 10b). In trench 3 the organic and clay content in the top soil furnished fairly high CEC with 15–20 $mmol_c$/100g being lower in the coarser textured soil layers between 0.5 and one metre to again increase in deeper layer with higher clay content. In trench 4, a fairly even distribution of CEC in the profile with about 7 $mmol_c$/100g in the upper layers, slightly higher c 12 $mmol_c$/100g in layers 1–2 m depth and again lower (c 5 $mmol_c$/100g) in deep layers (Figure 5-51 and Appendix 10b).

Acidity, Ac

Total acidity in the trench profiles of the Oskarshamn area shows fairly low values except for trench 5 where the high organic content gives values on 20–30 $mmol_c$/100g but in deep layers very low values occur. Such low values are also found in the deep layers of the other trenches. The special shell layer in trench 5 showed CEC values on 100 $mmol_c$/100g but there no acidity. In the upper part of the soil acidity are higher with in trench 1, 3–5 $mmol_c$/100g making up 10–25% of the exchange capacity (CEC). In deeper layers acidity was 25% of CEC. In trenches 3 and 4, acidity was very low below one metre depth with values often less then 0.001 $mmol_c$/100g making up negligible part of CEC. In the upper part of trench 3, the organic content provided higher acidity making up almost all CEC while conditions in trench 4 was different with acidity making up about 50% of CEC (Figure 5-51 and Appendix 10b).

Iron, Aluminium, Phosphorus

Iron, Fe

Iron is a common element in the soils and appears in several different forms being precipitated as hydroxides or complex bound the other elements and especially organic material. In the Oskarshamn area trenches, the stratification with depth showed similarities to several other elements and trenches 1 and 5 deviated from trenches 3 and 4 where the pattern with lower values in the top and bottom again appeared with top soil values of 2–3 g/kg for $Fe_{\textit{Aqua Regia}}$ and 1–3 g/kg for $Fe_{\text{Dit.citr.}}$ making up 30–70% of $Fe_{\textit{Aqua Regia}}$. In deeper layers the content of Fe increased and the ratios $Fe_{\text{Dit.citr.}}/Fe_{\textit{Aqua Regia}}$ were between 0.1–0.3. In trench 1, higher Fe content was found in the upper one metre with $Fe_{\textit{Aqua Regia}}$ on c 20 g/kg except for the very top soil. The ratio of $Fe_{\text{Dit.citr}}$ was about 25%. In the deeper layers $Fe_{\textit{Aqua Regia}}$ was c 10 g/kg with $Fe_{\text{Dit.citr}}$ being c 1 g/kg , i.e. 10%. Trench 5 furnished the more evenly distributed stratification with $Fe_{\textit{Aqua Regia}}$ of 5–10 g/kg and $Fe_{\text{Dit.citr}}$ on 1–7 g/kg actually decreasing with depth. This gave ratios in the upper soil layers on 0.5–0.75 but only 0.2 in the layers below 1.5 m (Figure 5-52 and Appendix 10b).

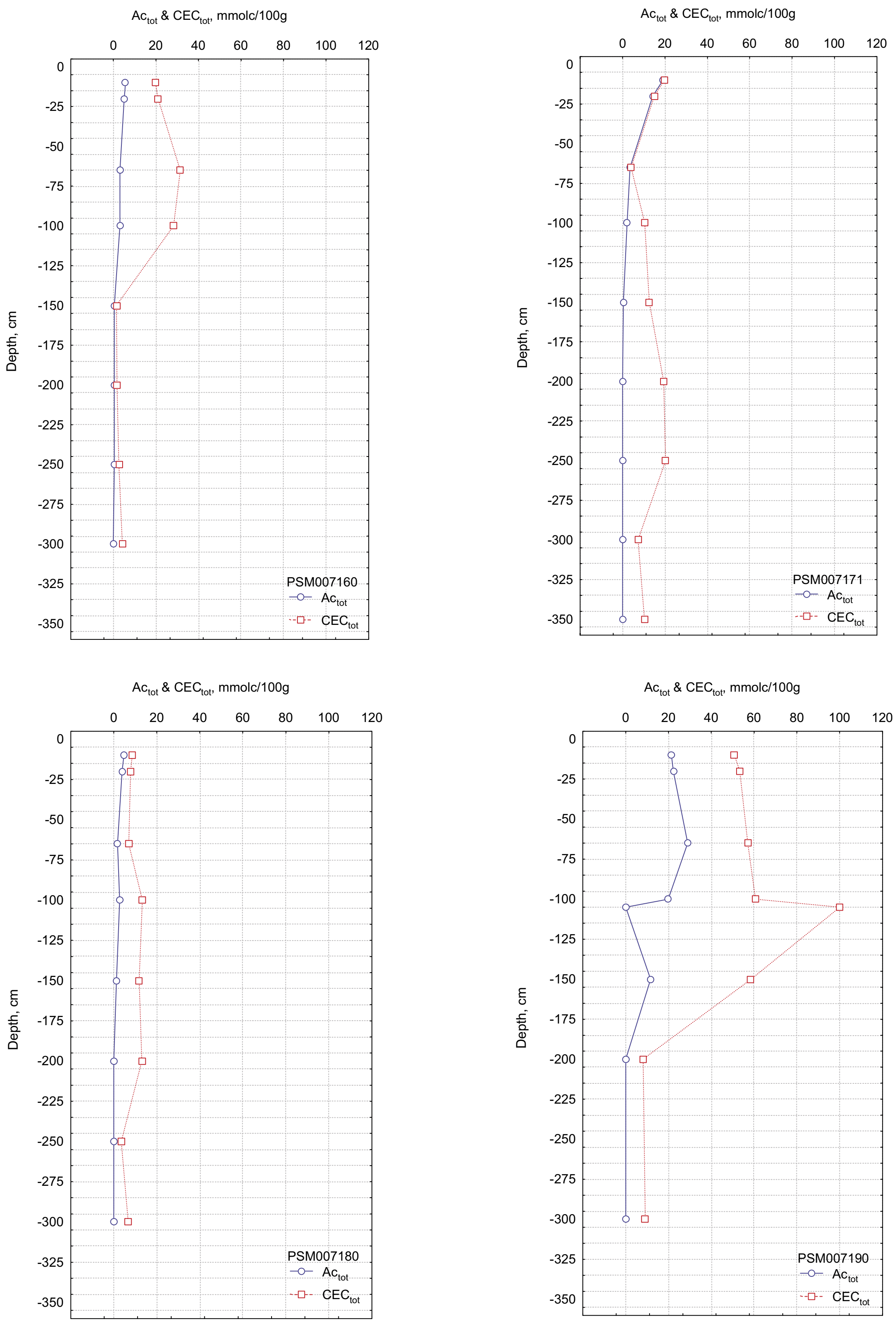


***Figure 5-51.** Acidity and CEC content stratification with soil depth in the profiles of the four trenches in the Oskarshamn area 2005. Two extractions; NH_4Ac, and Aqua Regia.*

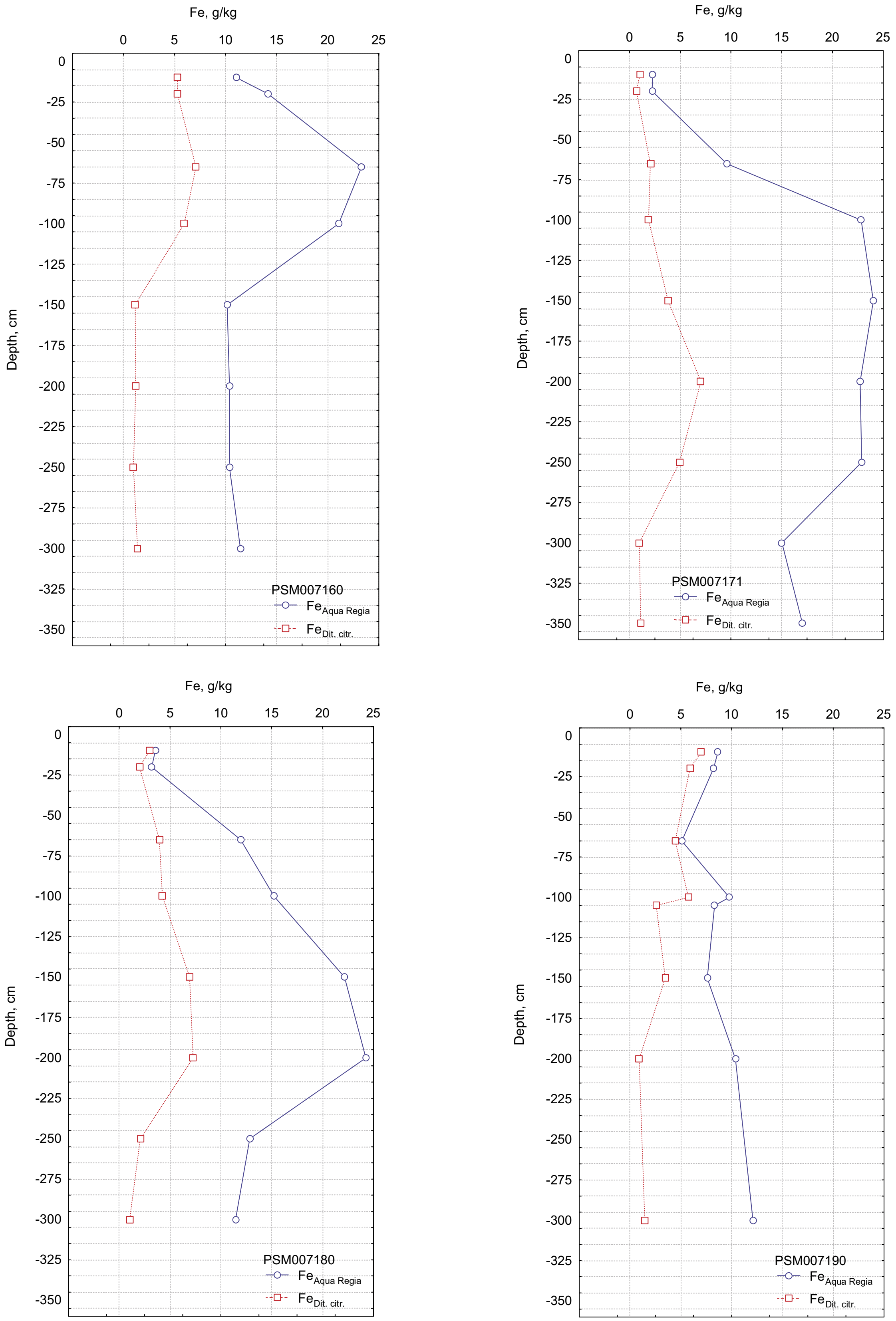


***Figure 5-52.** Fe content stratification with soil depth in the profiles of the four trenches in the Oskarshamn area 2005. Two extractions; Ditionit citrate, and Aqua Regia.*

Aluminium, Al

Aluminium being one of the most common elements in earth crust and contributing to soil acidity would also be connected to soil acidification. In the Oskarshamn area trenches the pattern from several elements and especially Fe could be seen. Deviating from this is the trench 5 with a more pronounced stratification as compared to elements such as base cations, Mn and Fe. Trench 1, however furnishes the ordinary pattern with high $Al_{\textit{Aqua Regia}}$ in the upper one metre being on 8–14 g/kg turning much lower at 3–6 g/kg below one metre. Relation to the ditionit citrate fraction showed ratios of 0.04–0.1 in the upper metre and c 0.02 in deeper layers.

Trenches 3 and 4 again had similar stratifications with lower contents $Al_{\textit{Aqua Regia}}$ of 3–6 g/kg and ratios to $Al_{\mathrm{Dit.citr.}}$ on 50–75% in the top soil layers. Further down in the profile $Al_{\textit{Aqua Regia}}$ increased to 12–16 g/kg with $Al_{\mathrm{Dit.citr.}}$ being 0.4–0.8 g/kg, i.e. ratio 0.04. In the deepest layers slightly lower values were found with 4–7 g/kg and c 0.01 g/kg, respectively, and giving a ratio of below 0.002. In trench 5 the Al content mainly decreased from 15 g/kg to c 4 g/kg for $Al_{\textit{Aqua Regia}}$ and from 7 g/kg to 0.1 for $Al_{\mathrm{Dit.citr.}}$ This gave ratios in the upper soil layers of 0.5 and much lower in the deep layers with 0.01 (Figure 5-53 and Appendix 10b).

Phosphorus, P

Phosphorus being a very important plant nutrient besides nitrogen and potassium could be strongly bound to mineral soils, especially Ca-rich soils and clay soils such as some of the ones in the Oskarshamn area trenches. Easily accessible P, reflecting mainly organically bound P, could be determined in AL-extracts (ammonia lactate) and concentrations in the organic rich soil horizon were 0.06–0.10 g/kg and could be compared to 0.02–0.10 g/kg in the Forsmark area. Stronger bound but potentially available P was determined in HCl extraction and these values were considerably higher, i.e. 0.2–1.2 g/kg and could be compared to c 0.3 g/kg in the Forsmark area. However, the influence of mineral soil contents was higher in the Oskarshamn area furnishing high contents.

For phosphorus similarities between the four trench profiles were greater as compared to most other elements. Mainly the P_{HCl} content increased from 0.2–0.4 g/kg in the upper soil layers to 0.6–1.0 g/kg in the deepest layers (Figure 5-54 and Appendix 10a). The share of easily accessible P_{AL} was mainly 20–30% but lower in trench 1 with 10% and in trench 4 above 1.5 m with 1–5%. Also in deep layers the share of P_{AL} was low with 5–10%.

High shares of P_{AL} were found in the middle parts of trench 3 and 4 with 30% and especially in trench 5 on one metre depth with almost 100%. Trench 5 deviated in two respects from the other profiles, i.e. one was a strong decrease in the upper one metre for P_{HCl} from q.2 g/kg to 0.1 g/kg and then again in the shell layer and below the stratification was even between 0.4 and 0.6 g/kg. Further it could be noticed that the high P_{HCL} content in the very top layers was not reflected in the P_{AL} content (Figure 5-54 and Appendix 10a).

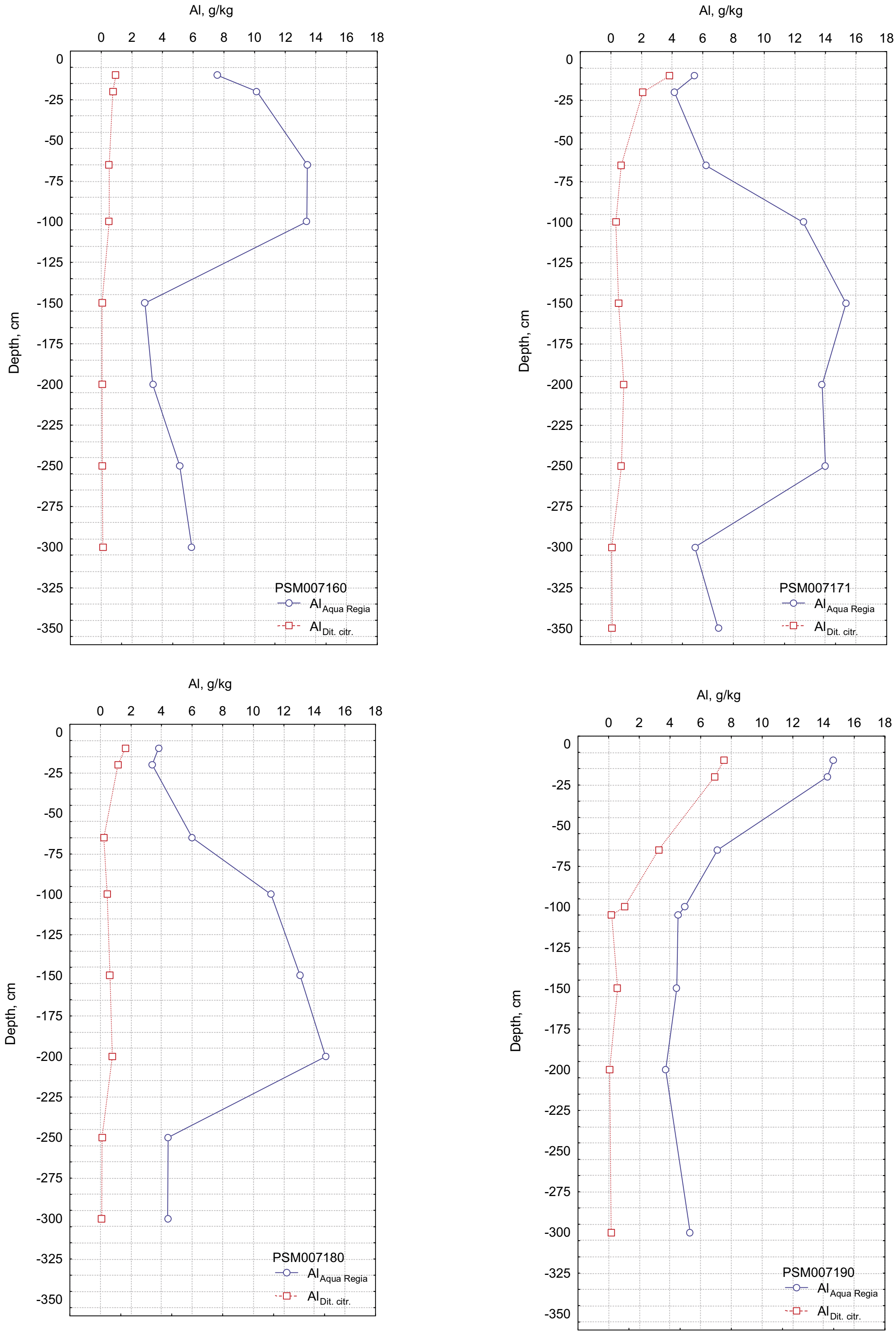


Figure 5-53. *Al content stratification with soil depth in the profiles of the four trenches in the Oskarshamn area 2005. Two extractions; Ditionit citrate, and Aqua Regia.*

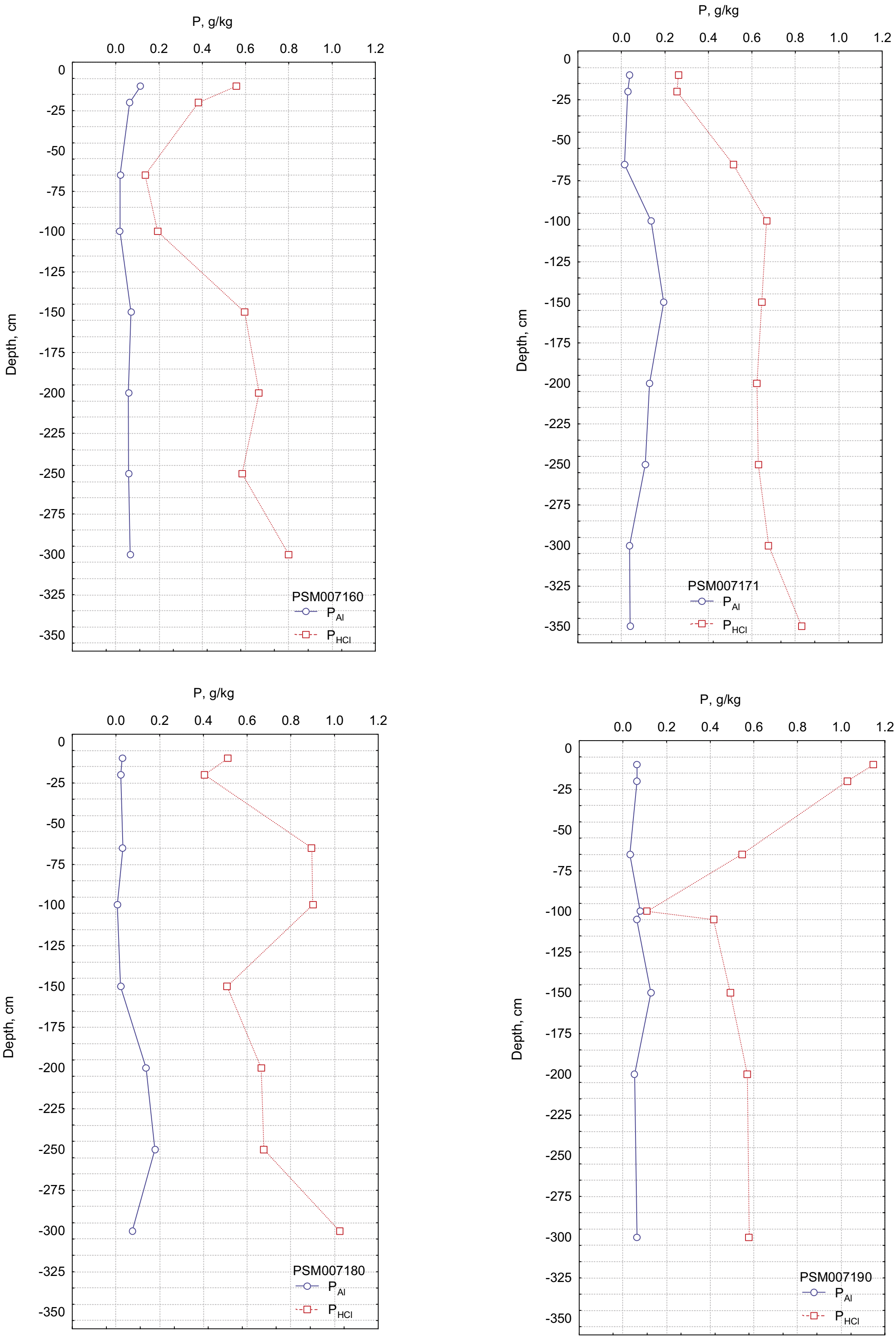


Figure 5-54. *Extractable phosphorus (P_{HCl} and pAL) content stratification with soil depth in trench profiles at the Oskarshamn area 2005. Two extractions: ammonium lactate and HCl.*

6 Summary

This report includes result from studies of soils, Quaternary deposits and bedrock in topographic lineaments situated in the Laxemar subarea. All these investigations include field classifications, whereas the studies of soils and Quaternary deposits also include analyses of the physical and chemical properties. The bedrock was documented in three and the soils in four machine dug trenches. The Quaternary deposits were documented and samples in the trenches but also during soil/rock drillings. Groundwater monitoring wells were installed at 9 of the drilled sites.

The bedrock in the three investigated trenches consists of Ävrö granite. The bedrock shows typical signs of brittle deformation in all three excavations i.e red staining/oxidation of rock groundmass, relatively high fracture frequency and presence of epidote, quartz and chlorite as fracture fillings. The strongest alteration was noted in excavation Profile 4, where the excavation revealed a 12 m long, continuos rock exposure in north-south direction, crosscutting a north-west–south-east trending fracture zone. The central part of the zone, c 4–5 m wide, consists of a strongly fractured and argillic altered bedrock with a c0.6 m wide core zone of red and green gouge.

All studied Quaternary deposits have probably been deposited during or after the latest glaciation The characteristic of the till indicates short distance of transportation and the mineral and chemical composition of the till reflects that of the local bedrock. The contents of most chemical elements are close to those of average Swedish till.

There is a small glaciofluvial deposit is in the eastern part of the Laxemar subarea. The deposit is resting directly upon the bedrock or at some places upon the till. Although small the deposit is locally several tens of metres thick (se below).

The glacial clay was deposited during the latest deglaciation when the water was relatively deep. As the water depth decreased streams and waves started to erode the uppermost clay and deposited a layer sand/gravel on top of the clay. The valleys, where the investigated sites are situated, became sheltered bays as the water depth decreased and post-glacial clays (e.g. clay gyttja and gyttja), containing organic material, started to deposit. The chemical conditions of these sediments partly reflect the nutrient rich conditions prevailing in the bays during sediment accumulation. The gyttja clay is often overlain by peat, which was formed in the wetlands that developed after the area has been lifted above the sea level. Man made ditches has drained many of the wetlands, which previously were present at the floor of many of the valleys.

Based on this and earlier investigations a general stratigraphy has been constructed for the Laxemar area, which from the bedrock and up, is as follows: till, glacial clay, sand/gravel, gyttja/gyttja clay and peat. The glaciofluvial deposit is not included in the stratigraphy.

The total depth of regolith at the drilled sites varies between 2.8 and 33.6 metres. The largest depth was recorded in a pronounced topographical lineament, which at the investigated site is covered by the glaciofluvial deposit mentioned above. It is possible that the glaciofluvial deposit is important for the groundwater properties in that particular valley. The glaciofluvial material has, however, a small surface extension and it is therefore unlikely that it affect the regional groundwater properties in the Laxemar subarea. Forthcoming groundwater monitoring and slug tests will hopefully resolve that question.

The four large trenches investigated, between 32 m and 7 m long, were located at four sites, mainly in low-lying locations on arable land and pastures. The soil profile types, in the total area, are mainly Regosol, Podzol, Umbrisol and Cambisol. Cambisol and Regosol are the dominant soil types at the investigated sites but Leptosol and Histosol also occur. Rooting depth partly reach great depths and at the most 2.4 m depth.

At the investigated sites the soil physical conditions are frequently influenced by high contents of clay and organic material, which influence the soil hydrology. Dry bulk density is fairly low and porosity is consequently high. High soil moisture retention coincides with low hydraulic conductivity. Only in the surface layers conductivity is somewhat higher.

Also the soil chemical conditions are frequently influenced by the high contents of organic material and clay. This furnishes fairly high pH both in the upper and deep soil layers. Carbon and nitrogen show the common 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 four investigated trenches. The overall content of elements were however in similar range and deviated from the large-scale contents of Sweden where the forested till soils furnish more poor conditions. At the sites investigated here, the land type of arable and pastures furnish comparably nutrient rich conditions.

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Appendix 1

Table A1-1. The stratigraphical distribution of QD as interpreted from the 15 drillings around the investigated profiles where soil sampling was carried out.

Profile	Id-code	From (m)	To (m)	Quaternary deposit
1	SSM000222	1.3	4.5	Sandy till
		4.50	7.2	Rock
1	SSM000223	0.0	0.6	Clay
		0.6	1.1	Sand
		1.1	7.8	Sandy till
		7.8	12.0	Rock
2	SSM000224	0.0	0.9	Artificial fill
		0.9	4.5	Glaciofluvial sand
		4.5	6.0	Glacial clay
		6.0	8.0	Glacial silt
		8.0	16.8	Glacial sand
		16.8	18.6	Sandy till
		18.6	21.2	Rock
2	SSM000225	0.0	0.8	Artificial fill
		0.8	4.8	Glaciofluvial sand
		4.8	5.4	Glacial clay
		5.4	8.8	Glaciofluvial sand
		8.8	9.8	Glaciofluvial gravel
2	PSM007148	0.0	5.5	Glaciofluvial sand
		5.5	6.0	Gravelly till
		6.0	8.0	Silty sand till
2	PSM007149	0.0	5.4	Glaciofluvial sand
		5.4	5.5	Till
2	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
2	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
2	PSM007152	0.0	0.5	Peat
		0.5	3.0	Glaciofluvial sand
2	PSM007153	0.0	0.4	Peat
		0.4	7.0	Glaciofluvial sand
3	SSM000226	0.0	0.6	Peat
		0.6	0.9	Gyttja clay
		0.9	1.2	Post-glacial sand
		1.2	2.4	Glacial clay

Profile	Id-code	From (m)	To (m)	Quaternary deposit
		2.4	5.0	Till
		5.0	8.0	Rock
3	SSM000227	0.0	0.6	Peat
		0.6	0.9	Gyttja clay
		0.9	1.3	Post-glacial sand
		1.3	1.4	Glacial clay
4	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
4	SSM000229	0.0	1.0	Silty till
		1.0	2.4	Boulder
		2.4	3.8	Sandy till
		3.8	7.0	Rock
Lilla Laxemar	SSM000230	0.0	4.6	Glaciofluvial sand
		4.6	7.6	Rock

Appendix 2

All soil descriptions based on system of notations for geotechnical investigations, Swedish Geotechnical Society (SGF), version 2001:2

LAXEMAR BOREHOLE PSM007148

Company rep.
Torbjörn Johansson

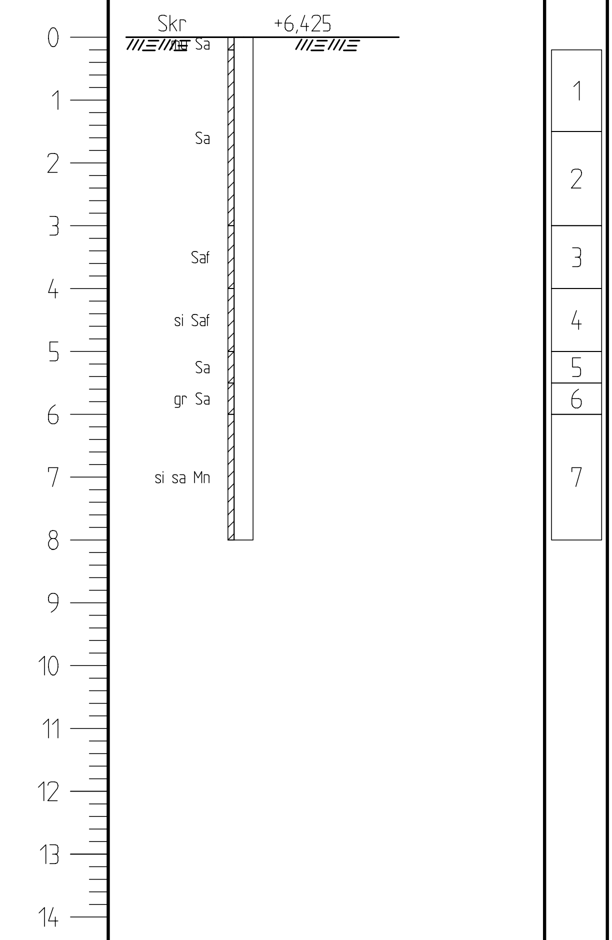
Client: Svensk Kärnbränslehantering AB

Northing :6368096,789
Easting :1548661,316

Coordinate system : RT90-RHB70

Date of completion: 2005-08-25

Depth (m)	Description	Samples	



GEOLOGICAL LOG

0-0,2m	humus-bearing sand
0,2-3,0m	sand
3,0-4,0m	fine sand
4,0-5,0m	silty fine sand
5,0-5,5m	sand
5,5-6,0m	gravelly sand
6,0-8,0m	silty sandy till

LAXEMAR BOREHOLE PSM007149

Company rep.
Torbjörn Johansson

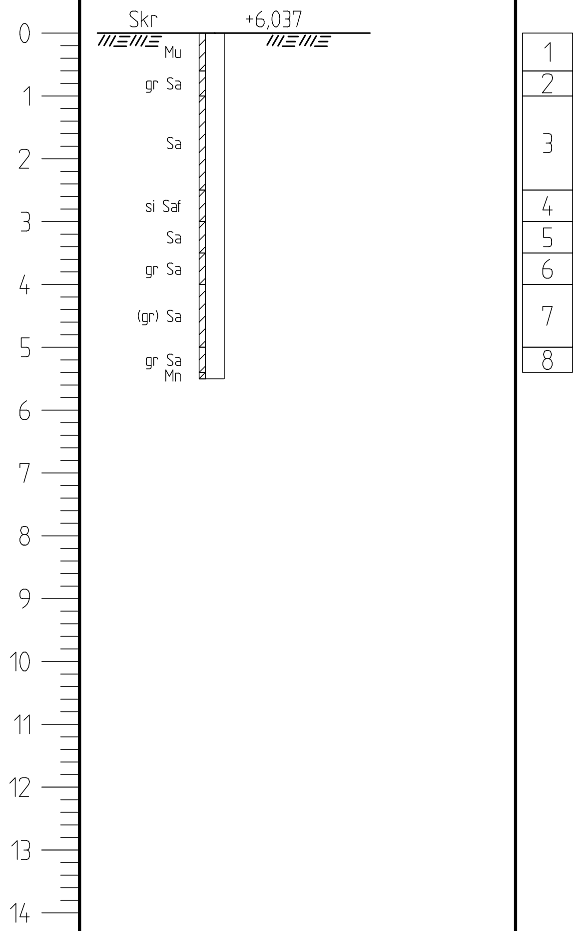
Client: Svensk Kärnbränslehantering AB

Northing :6368103,250
Easting :1548625,099

Coordinate system : RT90-RHB70

Date of completion: 2005-08-25

Depth (m)	Description	Samples	



GEOLOGICAL LOG

0-0,6m	topsoil
0,6-1,0m	gravelly sand
1,0-2,5m	sand
2,5-3,0m	silty fine sand
3,0-3,5m	sand
3,5-4,0m	gravelly sand
4,0-5,0m	somewhat gravelly sand
5,0-5,4m	gravelly sand
5,4-5,5m	fill

LAXEMAR BOREHOLE PSM007150

Company rep.
Torbjörn Johansson

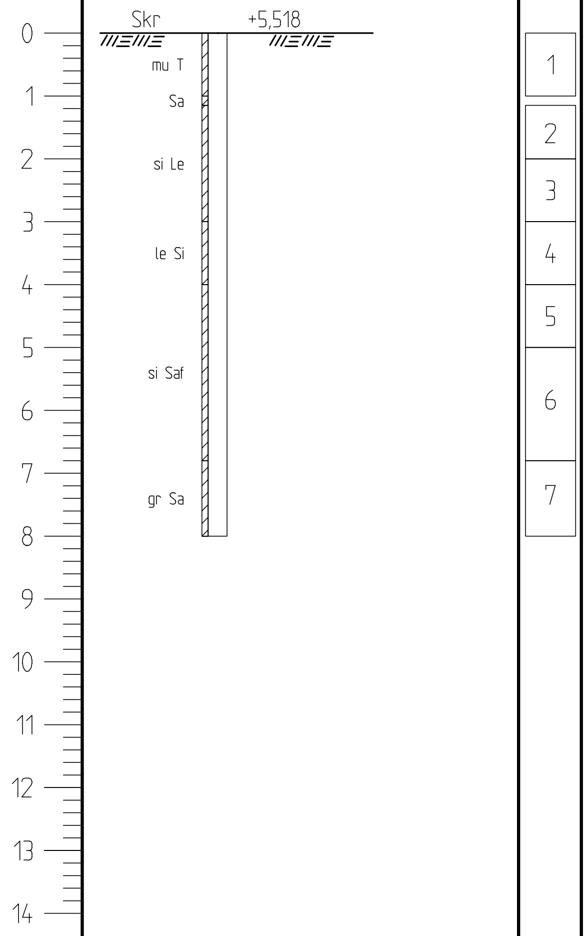
Client: Svensk Kärnbränslehantering AB

Northing :6368107,436
Easting :1548571,309

Coordinate system : RT90-RHB70

Date of completion: 2005-09-07

Depth (m)	Description	Samples	



GEOLOGICAL LOG

0-1,0m	humus-bearing peat
1,0-1,15m	sand
1,15-3,0m	silty clay
3,0-4,0m	clayey silt
4,0-6,8m	silty fine sand
6,8-8,0m	gravelly sand

LAXEMAR BOREHOLE PSM007151

Company rep.
Torbjörn Johansson

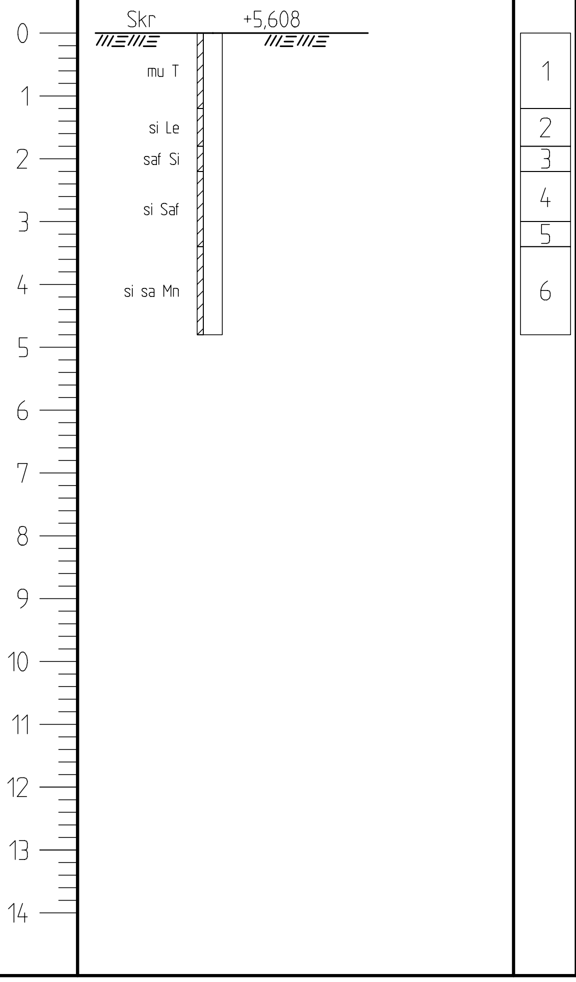
Client: Svensk Kärnbränslehantering AB

Northing :6368108,775
Easting :1548524,107

Coordinate system : RT90-RHB70

Date of completion: 2005-09-07

Depth (m)	Description	Samples	



GEOLOGICAL LOG

0-1,2m	humus-bearing peat
1,2-1,8m	silty clay
1,8-2,2m	fine sandy silt
2,2-3,4m	silty fine sand
3,4-4,8m	silty sandy till

LAXEMAR BOREHOLE PSM007152

Company rep.
Torbjörn Johansson

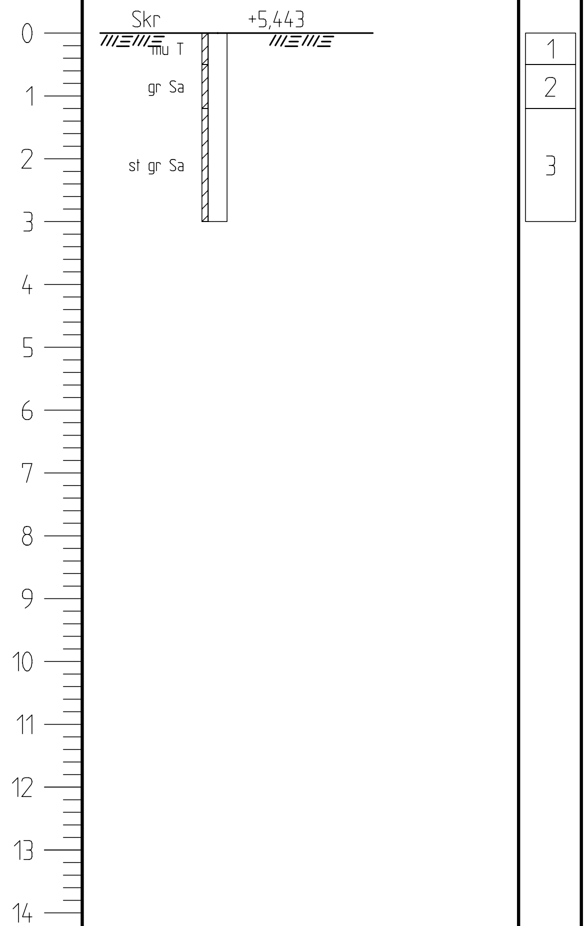
Client: Svensk Kärnbränslehantering AB

Northing :6368105,942
Easting :1548595,665

Coordinate system : RT90-RHB70

Date of completion: 2005-09-07

Depth (m)	Description	Samples	



GEOLOGICAL LOG

0-0,5m humus-bearing peat
0,5-1,2m gravelly sand
1,2-3,0m cobble-bearing gravelly sand

LAXEMAR BOREHOLE PSM007153

Company rep.
Torbjörn Johansson

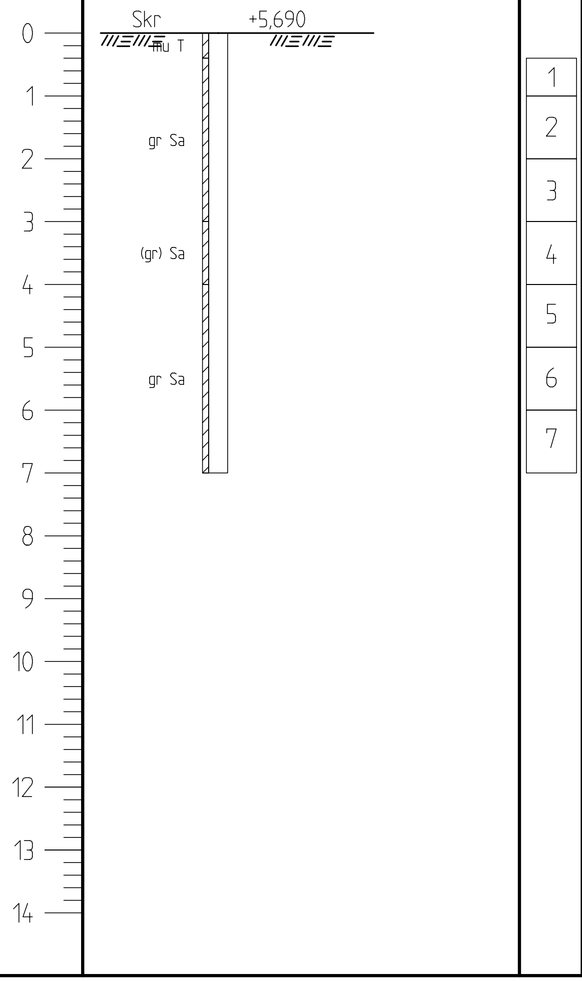
Client: Svensk Kärnbränslehantering AB

Northing :6368105,333
Easting :1548607,241

Coordinate system : RT90-RHB70

Date of completion: 2005-09-07

Depth (m)	Description	Samples	



GEOLOGICAL LOG

0-0,4m humus-bearing peat
0,4-3,0m gravelly sand
3,0-4,0m somewhat gravelly sand
4,0-7,0m gravelly sand

LAXEMAR BOREHOLE PSM007200

Company rep.
Torbjörn Johansson

Client: Svensk Kärnbränslehantering AB

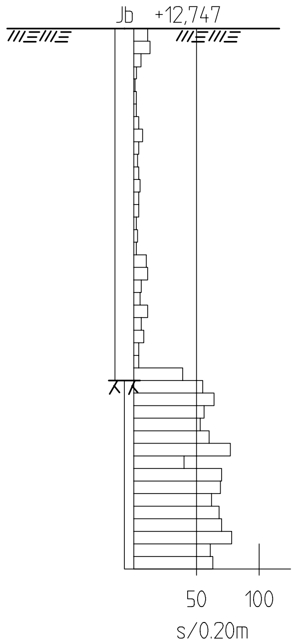
Northing :6367175,029
Easting :1547500,388

Coordinate system : RT90-RHB70

Date of completion: 2005-08-22

Depth (m)	Description	Samples	

Depth (m): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14



GEOLOGICAL LOG

5,6m rock surface

LAXEMAR BOREHOLE PSM007201

Company rep.
Torbjörn Johansson

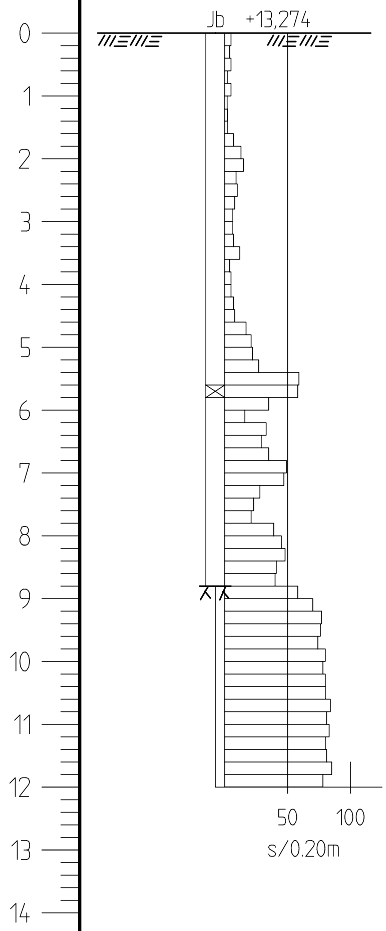
Client: Svensk Kärnbränslehantering AB

Northing :6367171,141
Easting :1547523,551

Coordinate system : RT90-RHB70

Date of completion: 2005-08-23

Depth (m)	Description	Samples	



GEOLOGICAL LOG

5,6-5,8m Boulders
8,8m rock surface

LAXEMAR BOREHOLE PSM007202

Company rep.
Torbjörn Johansson

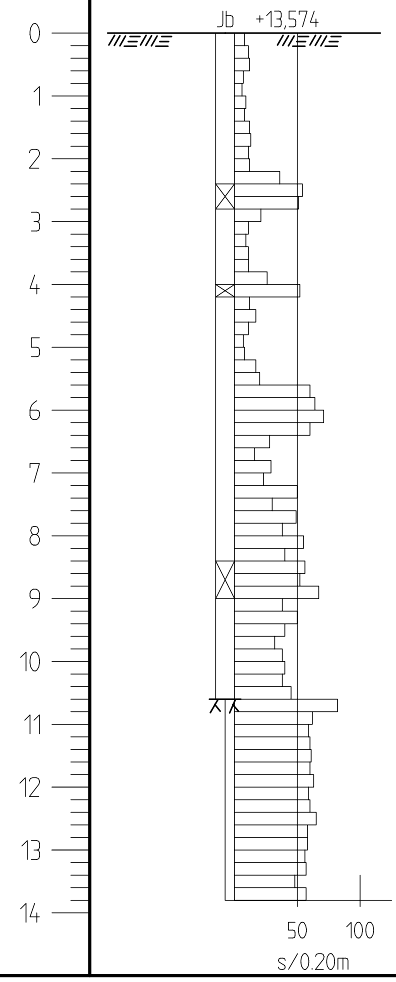
Client: Svensk Kärnbränslehantering AB

Northing :6367170,367
Easting :1547536,465

Coordinate system : RT90-RHB70

Date of completion: 2005-08-23

Depth (m)	Description	Samples	



GEOLOGICAL LOG

2,4-2,8m Boulders
4,0-4,2m boulders
8,4-9,0m boulders
10,6m rock surface

LAXEMAR BOREHOLE PSM007203

Company rep.
Torbjörn Johansson

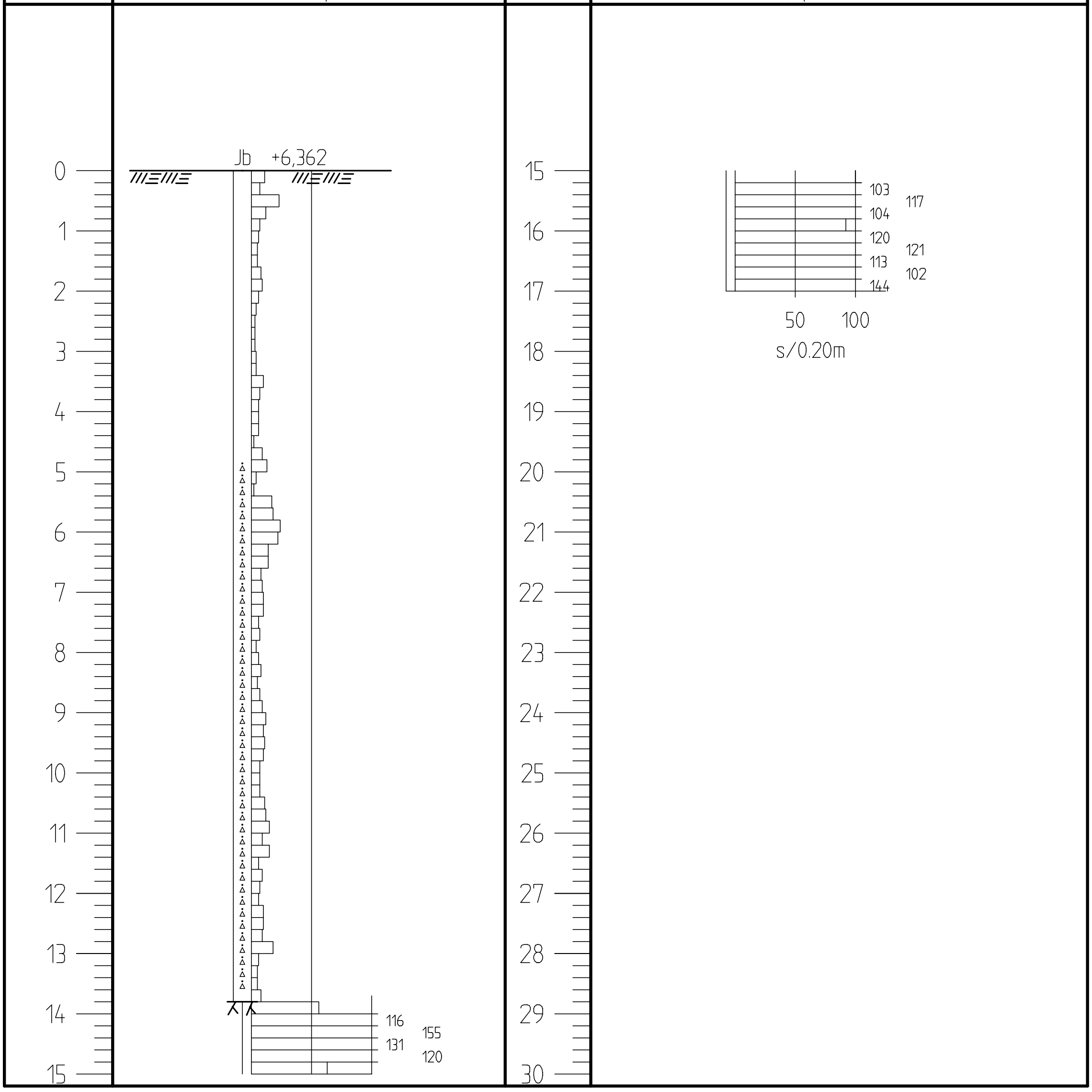
Client: Svensk Kärnbränslehantering AB

Northing :6368102,226
Easting :1548660,283

Coordinate system : RT90-RHB70

Date of completion: 2005-08-29

Depth (m)	Description	Depth (m)	Description



LAXEMAR BOREHOLE PSM007204

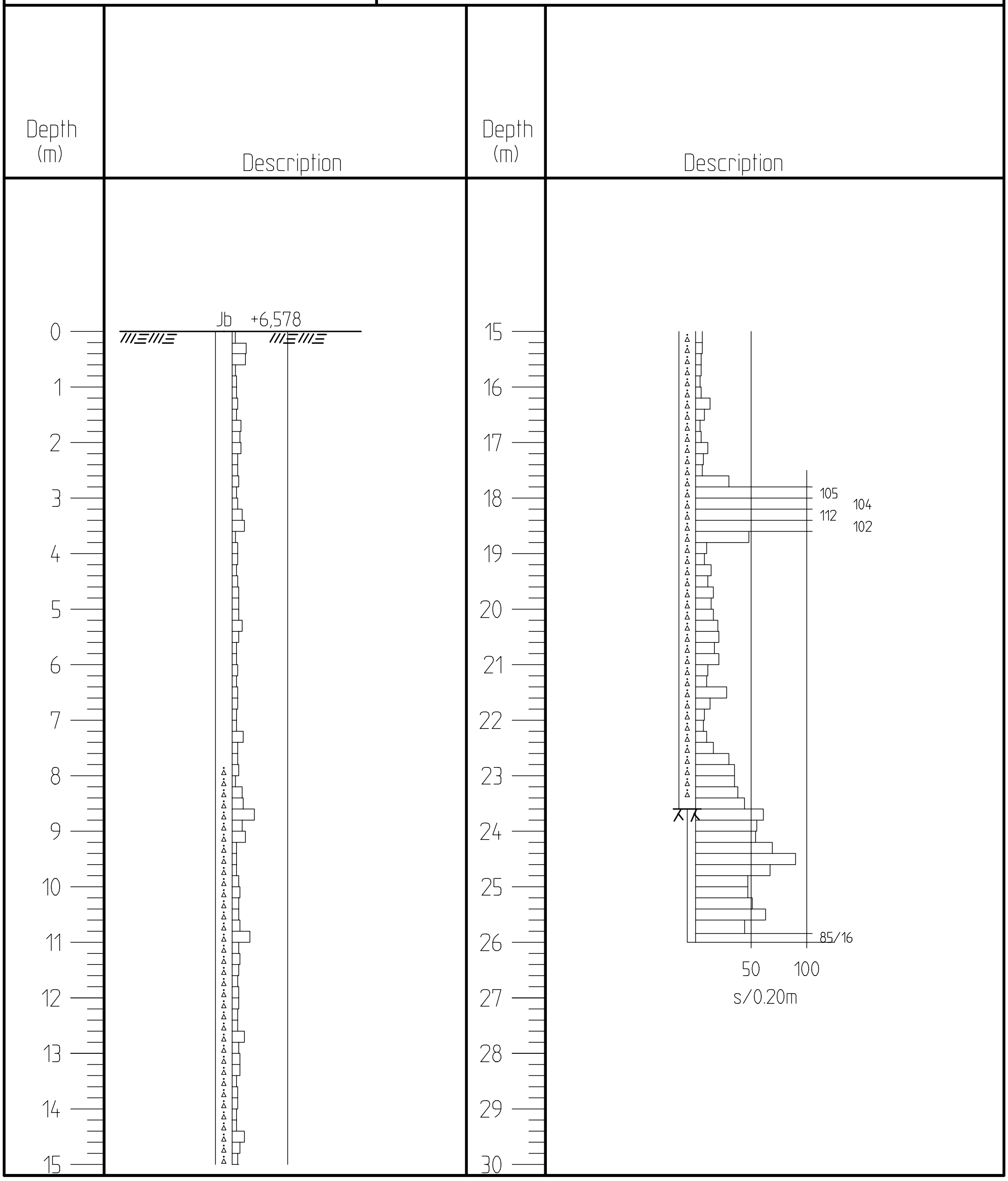
Company rep.
Torbjörn Johansson

Client: Svensk Kärnbränslehantering AB

Northing :6368085,694
Easting :1548665,773

Coordinate system : RT90-RHB70

Date of completion: 2005-08-29



LAXEMAR BOREHOLE PSM007205

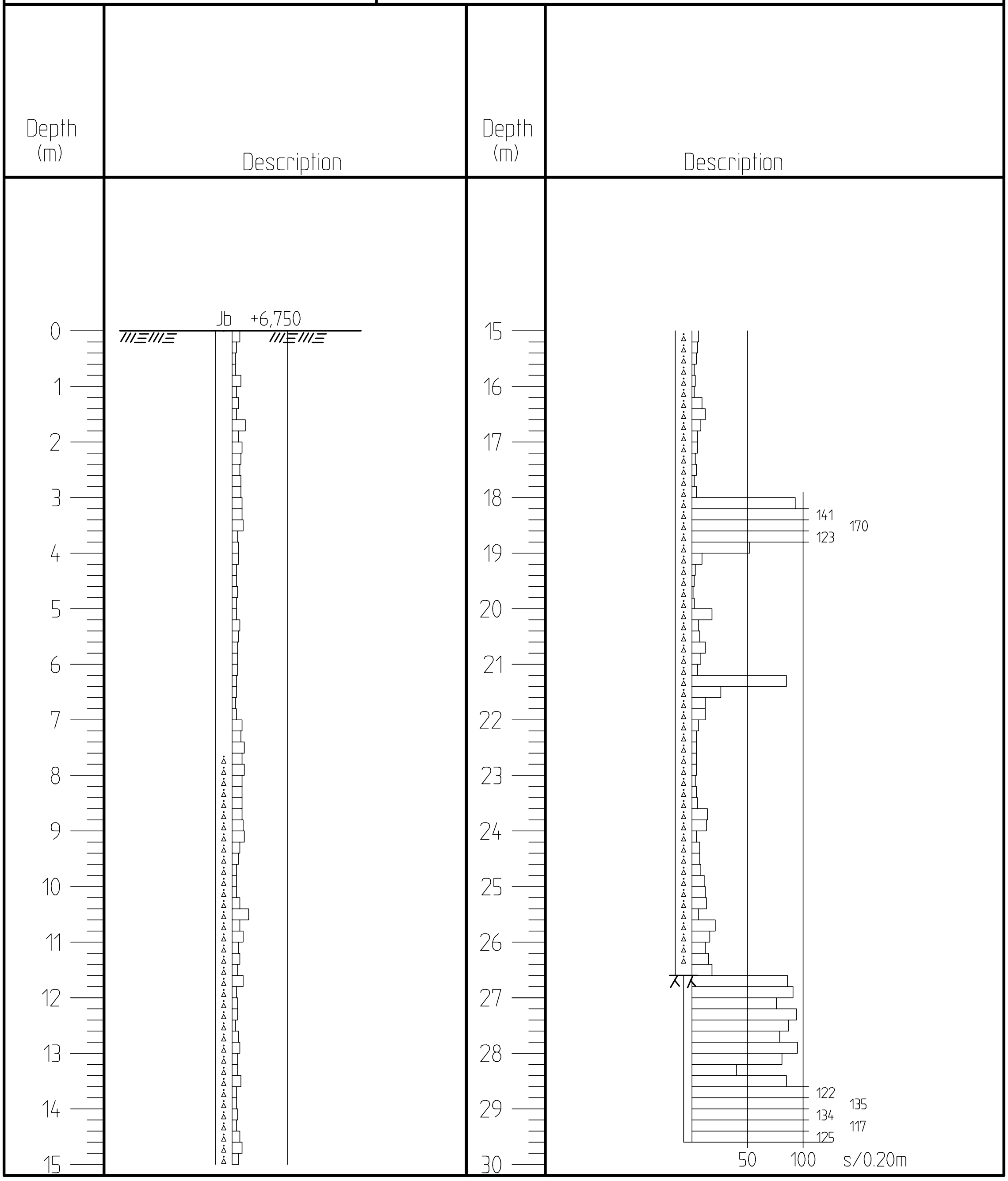
Company rep.
Torbjörn Johansson

Client: Svensk Kärnbränslehantering AB

Northing :6368070,736
Easting :1548672,853

Coordinate system : RT90-RHB70

Date of completion: 2005-08-30



LAXEMAR BOREHOLE PSM007206

Company rep.
Torbjörn Johansson

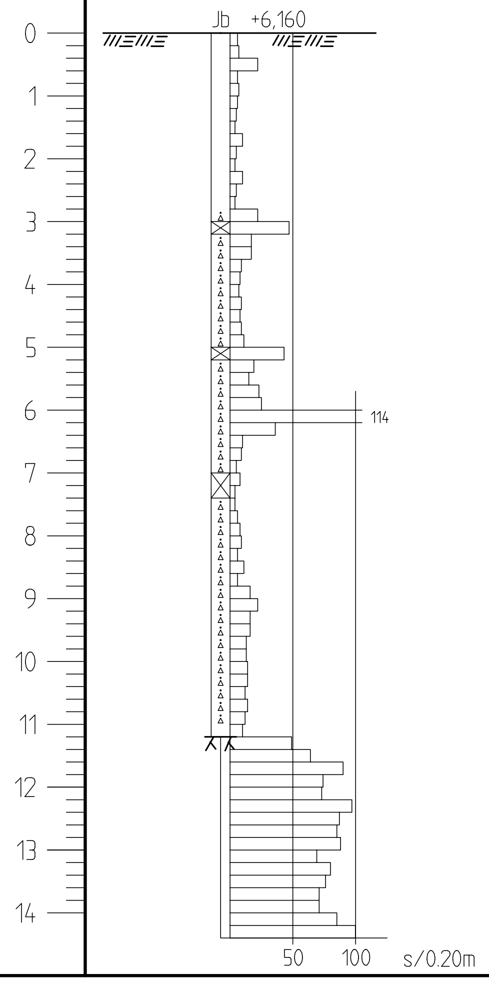
Client: Svensk Kärnbränslehantering AB

Northing :6368114,143
Easting :1548655,468

Coordinate system : RT90-RHB70

Date of completion: 2005-08-30

Depth (m)	Description	Samples	



GEOLOGICAL LOG

3,0-3,2m	boulders
5,0-5,2m	boulders
7,0-7,4m	boulders
11,2m	rock surface

LAXEMAR BOREHOLE PSM007207

Company rep.
Torbjörn Johansson

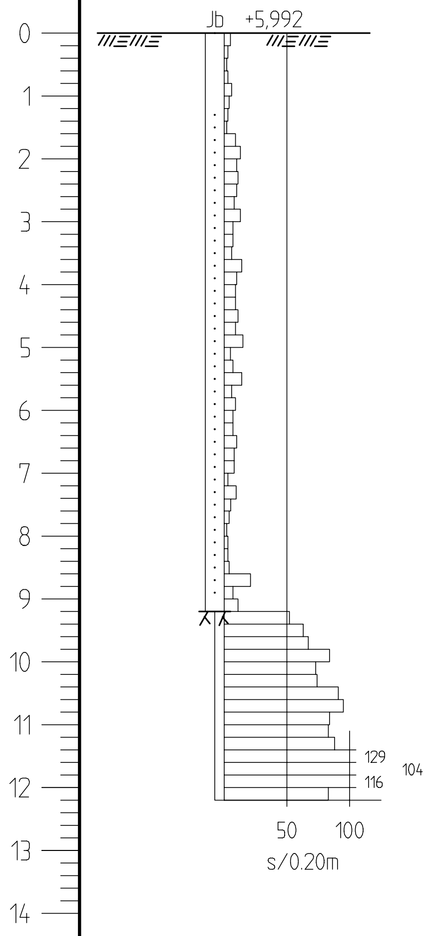
Client: Svensk Kärnbränslehantering AB

Northing :6368125,078
Easting :1548646,659

Coordinate system : RT90-RHB70

Date of completion: 2005-08-30

Depth (m)	Description	Samples	



GEOLOGICAL LOG

9,2m rock surface

LAXEMAR BOREHOLE PSM007208

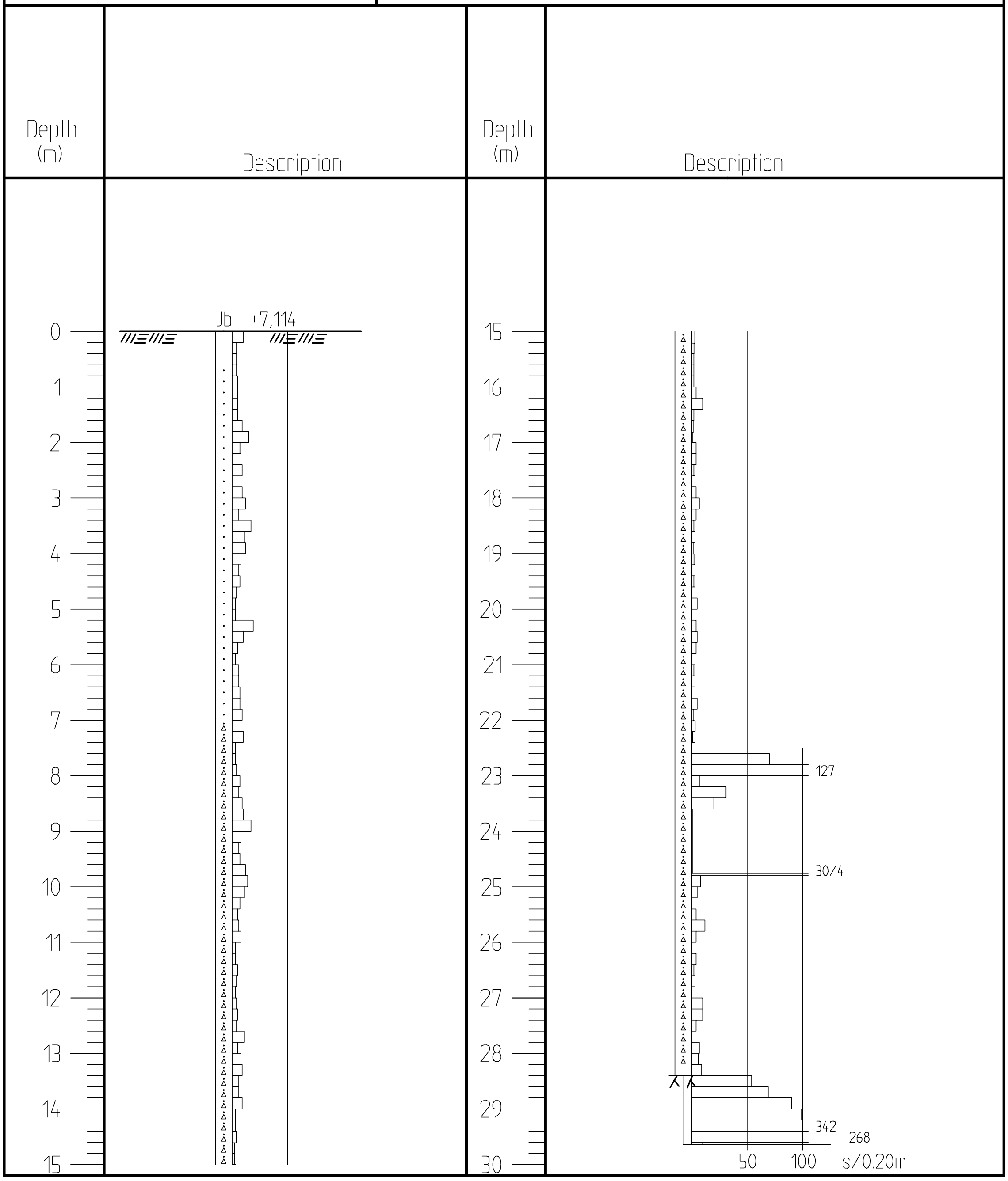
Company rep.
Torbjörn Johansson

Client: Svensk Kärnbränslehantering AB

Northing :6368058,601
Easting :1548675,409

Coordinate system : RT90-RHB70

Date of completion: 2005-08-30



LAXEMAR BOREHOLE PSM007209

Company rep.
Torbjörn Johansson

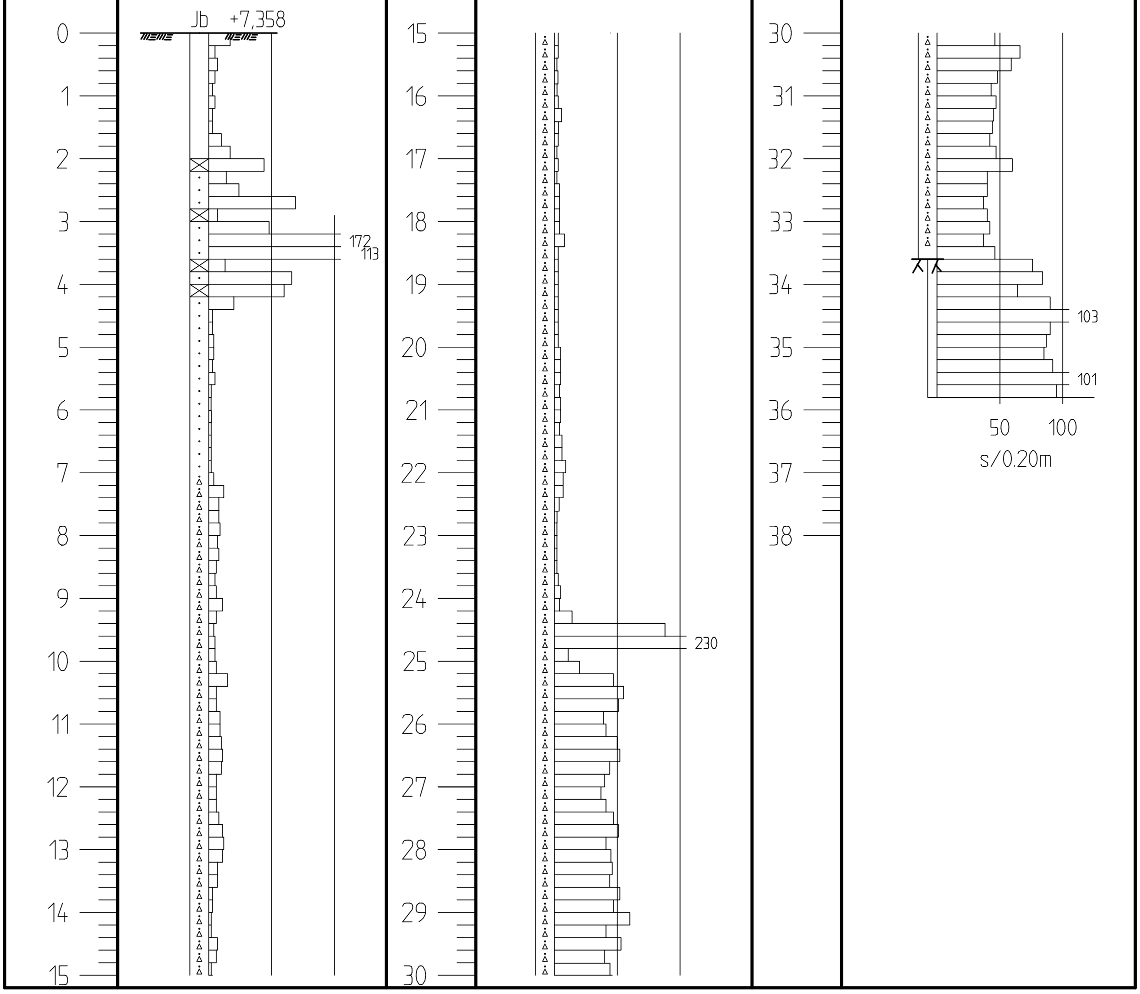
Client: Svensk Kärnbränslehantering AB

Northing :6368047,288
Easting :1548678,187

Coordinate system : RT90-RHB70

Date of completion: 2005-08-31

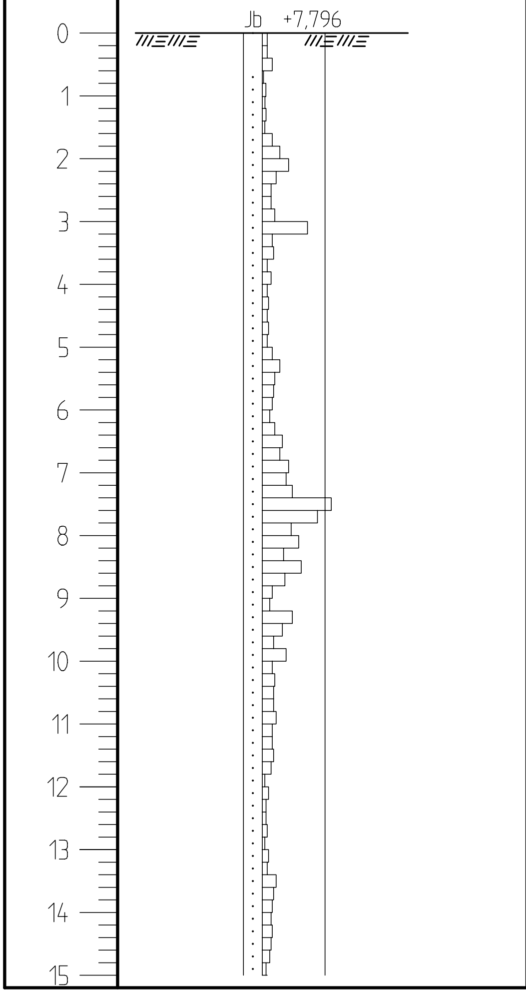
Depth (m)	Description	Depth (m)	Description	Depth (m)	Description

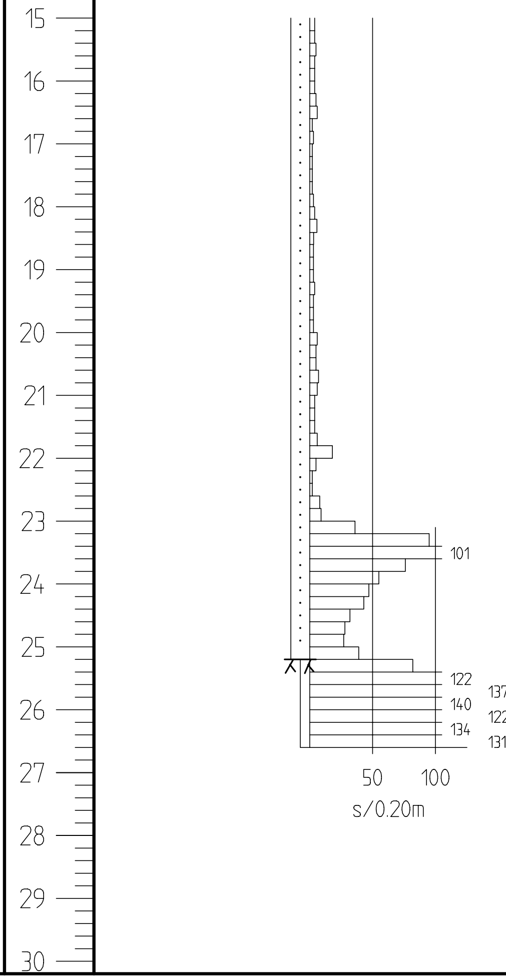


LAXEMAR BOREHOLE PSM007210

Company rep. Torbjörn Johansson Client: Svensk Kärnbränslehantering AB	Northing :6368035,577 Easting :1548681,049 Coordinate system : RT90-RHB70 Date of completion: 2005-08-31

Depth (m)	Description	Depth (m)	Description





WSP

LAXEMAR BOREHOLE PSM007211

Company rep.
Torbjörn Johansson

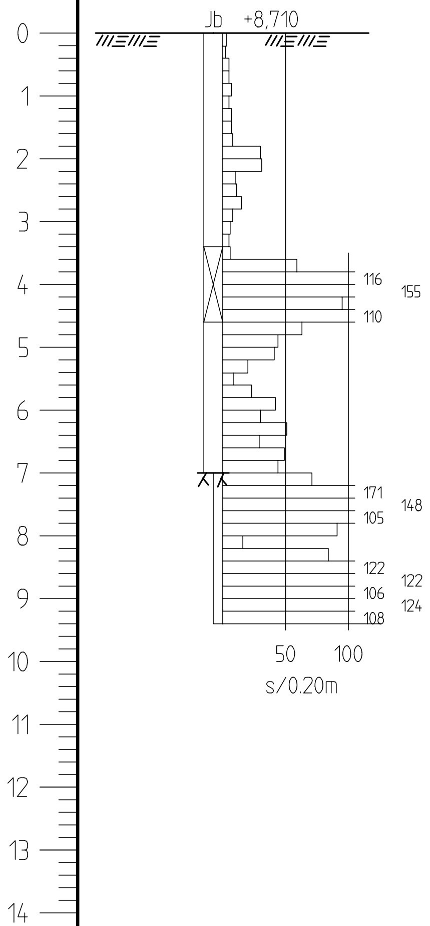
Client: Svensk Kärnbränslehantering AB

Northing :6368014,043
Easting :1548685,541

Coordinate system : RT90-RHB70

Date of completion: 2005-08-31

Depth (m)	Description	Samples	



GEOLOGICAL LOG

3,4-4,6m boulders
7,0m rock surface

LAXEMAR BOREHOLE PSM007212

Company rep.
Torbjörn Johansson

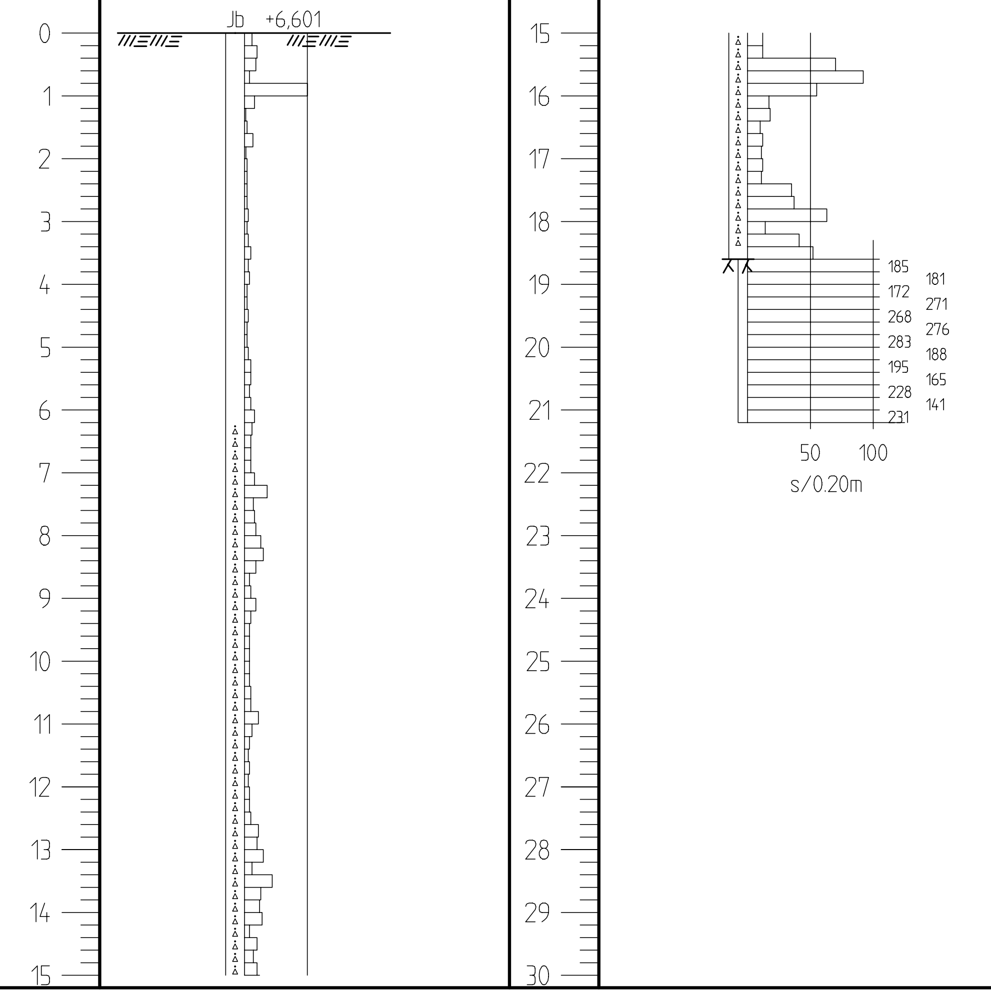
Client: Svensk Kärnbränslehantering AB

Northing :6368095,376
Easting :1548667,204

Coordinate system : RT90-RHB70

Date of completion: 2005-08-29

Depth (m)	Description	Depth (m)	Description



LAXEMAR BOREHOLE PSM007213

Company rep.
Torbjörn Johansson

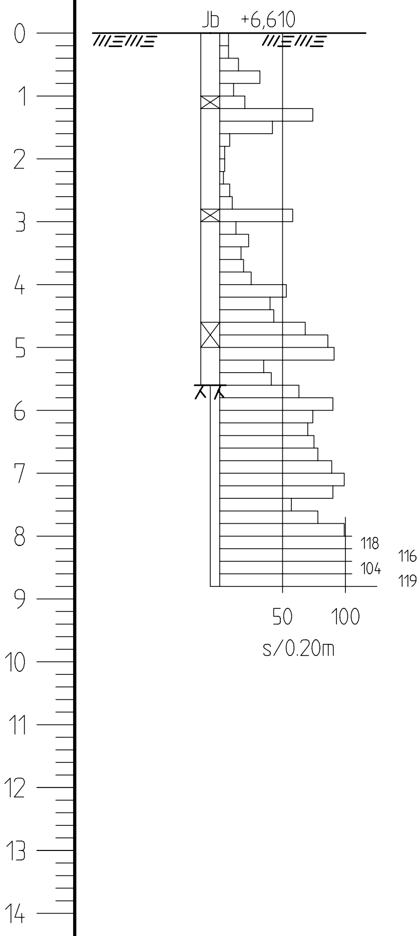
Client: Svensk Kärnbränslehantering AB

Northing :6367730,737
Easting :1549800,977

Coordinate system : RT90-RHB70

Date of completion: 2005-09-12

Depth (m)	Description	Samples	



GEOLOGICAL LOG

1,0-1,2m	boulders
2,8-3,0m	boulders
4,6-5,0m	boulders
5,6m	rock surface

LAXEMAR BOREHOLE PSM007214

Company rep.
Torbjörn Johansson

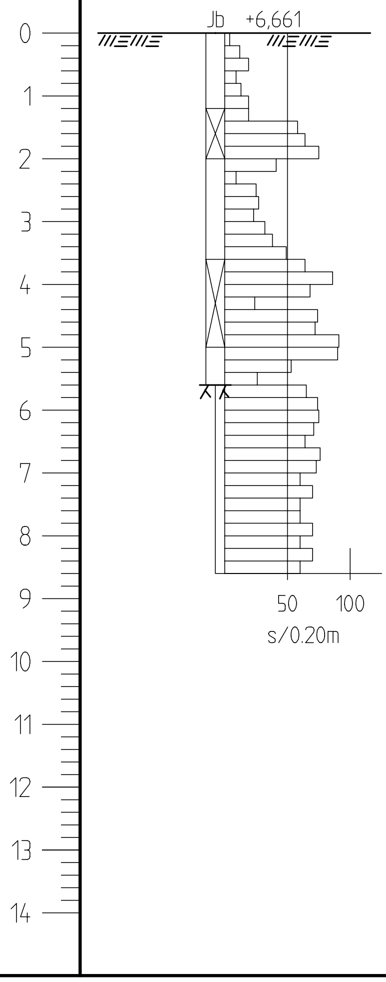
Client: Svensk Kärnbränslehantering AB

Northing :6367729,077
Easting :1549803,155

Coordinate system : RT90-RHB70

Date of completion: 2005-09-13

Depth (m)	Description	Samples	



GEOLOGICAL LOG

1,2–2,0m boulders
3,6–5,0m boulders
5,6m rock surface

LAXEMAR BOREHOLE PSM007215

Company rep.
Torbjörn Johansson

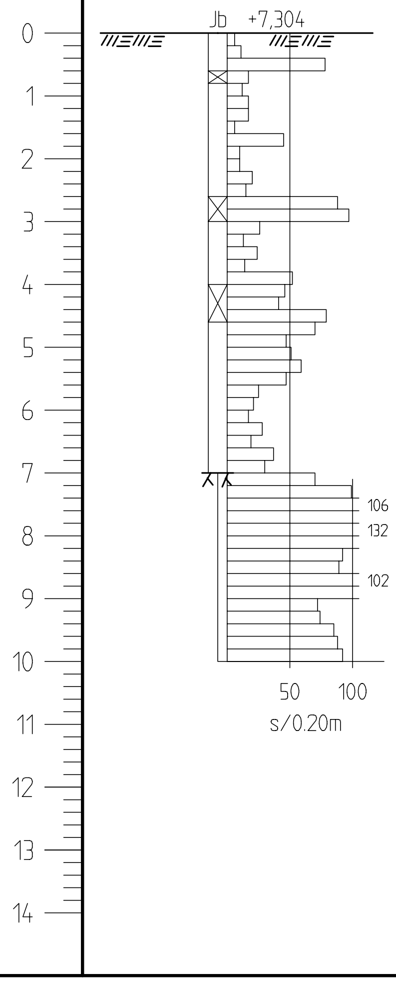
Client: Svensk Kärnbränslehantering AB

Northing :6367724,545
Easting :1549808,199

Coordinate system : RT90-RHB70

Date of completion: 2005-09-13

Depth (m)	Description	Samples	



GEOLOGICAL LOG

0,6-0,8m	boulders
2,6-3,0m	boulders
4,0-4,6m	boulders
7,0m	rock surface

WSP

LAXEMAR BOREHOLE PSM007216

Company rep.
Torbjörn Johansson

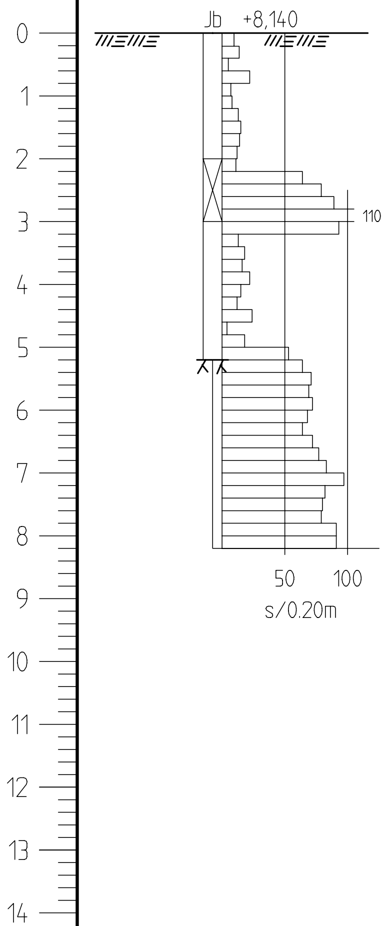
Client: Svensk Kärnbränslehantering AB

Northing :6367723,394
Easting :1549811,972

Coordinate system : RT90-RHB70

Date of completion: 2005-09-13

Depth (m)	Description	Samples	



GEOLOGICAL LOG

2,0-3,0m boulders
5,2m rock surface

WSP

LAXEMAR BOREHOLE PSM007217

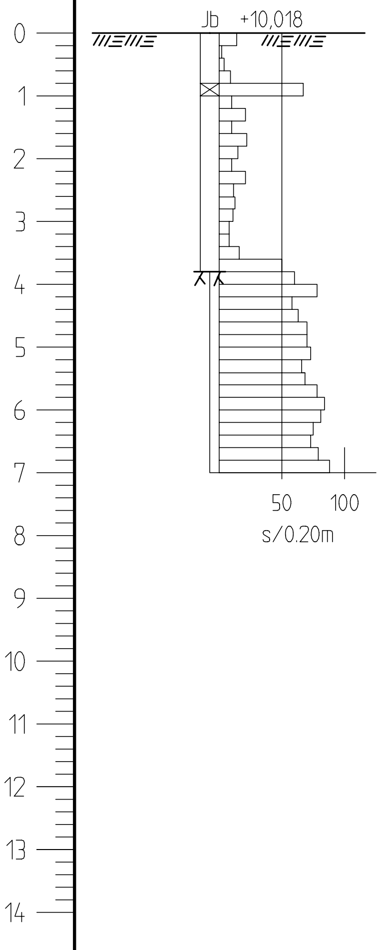
Company rep.
Torbjörn Johansson

Northing :6367720,799
Easting :1549817,938

Coordinate system : RT90-RHB70

Date of completion: 2005-09-13

Client: Svensk Kärnbränslehantering AB

Depth (m)	Description	Samples	
0–14			GEOLOGICAL LOG 0,8-1,0m boulders 3,8m rock surface

WSP

LAXEMAR BOREHOLE PSM007218

Company rep.
Torbjörn Johansson

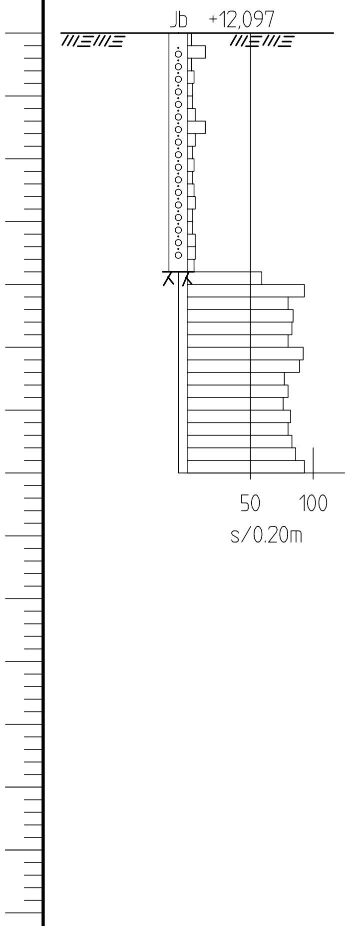
Client: Svensk Kärnbränslehantering AB

Northing :6366495,027
Easting :1548719,083

Coordinate system : RT90-RHB70

Date of completion: 2005-09-16

Depth (m)	Description	Samples	



GEOLOGICAL LOG

3,8m rock surface

LAXEMAR BOREHOLE PSM007219

Company rep.
Torbjörn Johansson

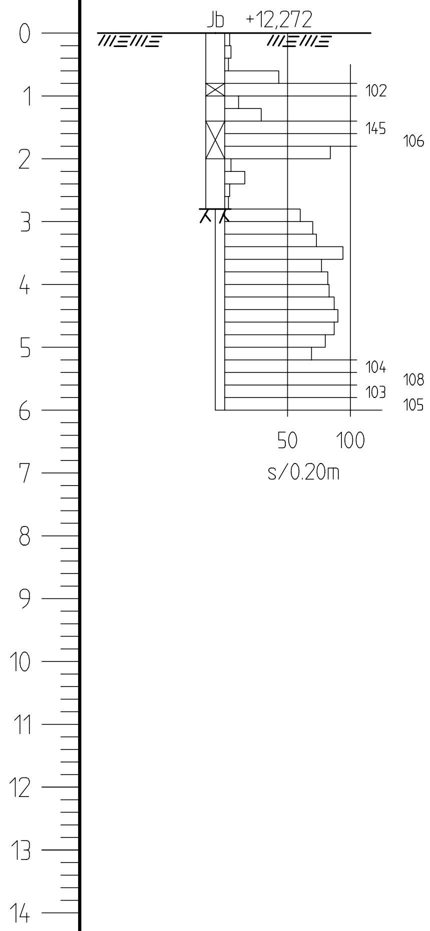
Client: Svensk Kärnbränslehantering AB

Northing :6366485,380
Easting :1548720,978

Coordinate system : RT90-RHB70

Date of completion: 2005-09-16

Depth (m)	Description	Samples	



GEOLOGICAL LOG

0,8-1,0m boulders
1,4-2,0m boulders
2,8m rock surface

LAXEMAR BOREHOLE SSM000222

Company rep.
Torbjörn Johansson

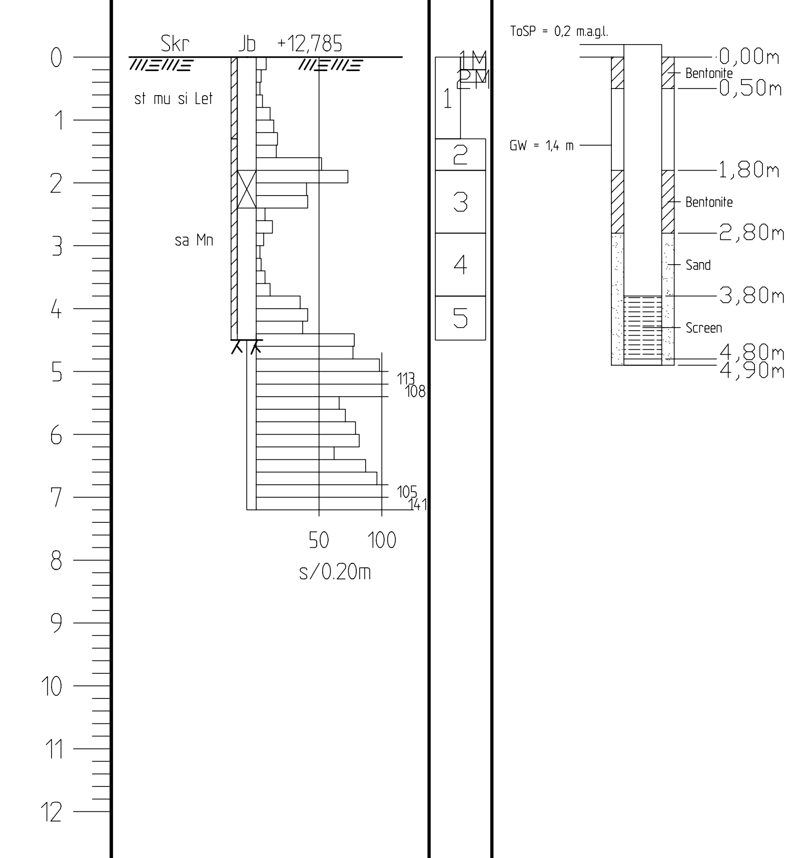
Client: Svensk Kärnbränslehantering AB

Northing : 6367190,616
Easting : 1547490,981

Coordinate system : RT90-RHB70

Top of stand pipe : 0,2 m.a.g.l.
Total pipe length : 5,10 m
Groundwater level : 1,4 m.b.g.l.
Date of completion : 2005-08-22

Depth (m)	Description	Samples	Groundwater monitoring well description	Borehole Construction Information



Drilling method : NOEK
Borehole diameter : 120 mm
sampling method : Auger

CASING
Material : PEH
Outer diameter : 63 mm
Inner diameter : 50 mm
Total length : 4,00 m

SCREEN
Material : PEH
Outer diameter : 63 mm
Inner diameter : 50 mm
Total length : 1,00 m
Slot : 0,3 mm

ANNULUS SEAL
Material : Bentonite clay
Total length : 1,50 m

SAND PACK
Grain size : 0,4-0,8 mm
Total length : 2.10 m

DRILLING EQUIPMENT
Drilling rig : GM 65 GTT
Drill hammer : Furukawa HB2G
Drill rod : Geostång Ø44
Drill bit : Stift Ø54

GEOLOGICAL LOG
0-1,3m cobble- and humus bearing silty dry crust of clay
1,3-4,5m sandy fill
4,5m rock surface

ToSP : Top of Stand Pipe
m.a.g.l. : meters above ground level
m.b.g.l. : meters below ground level

LAXEMAR BOREHOLE SSM000223

Company rep.
Torbjörn Johansson

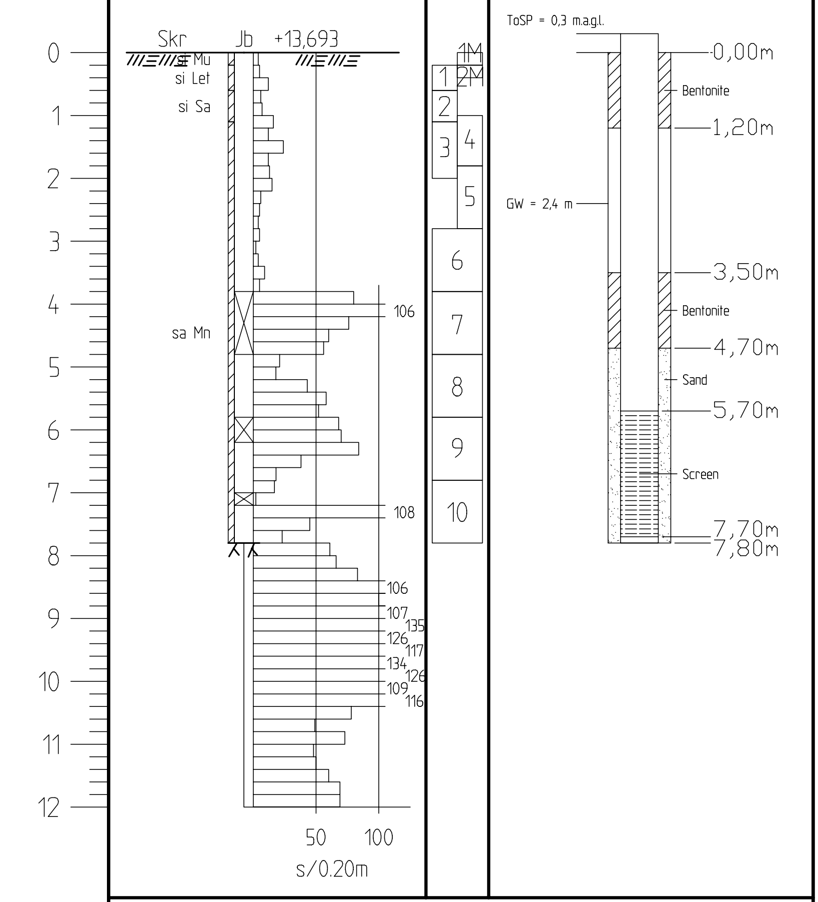
Client: Svensk Kärnbränslehantering AB

Northing :6367171,742
Easting :1547513,653

Coordinate system : RT90-RHB70

Top of stand pipe : 0,30 m.a.g.l.
Total pipe length : 8,10 m
Groundwater level : 2,4 m.b.g.l.
Date of completion : 2005-08-24

Depth (m)	Description	Samples	Groundwater monitoring well description	Borehole Construction Information



Drilling method : NOEK
Borehole diameter : 120 mm
sampling method : Auger

CASING
Material : PEH
Outer diameter : 63 mm
Inner diameter : 50 mm
Total length : 6,00 m

SCREEN
Material : PEH
Outer diameter : 63 mm
Inner diameter : 50 mm
Total length : 2,00 m
Slot : 0,3 mm

ANNULUS SEAL
Material : Bentonite clay
Total length : 2.40 m

SAND PACK
Grain size : 0,4-0,8 mm
Total length : 3,10 m

DRILLING EQUIPMENT
Drilling rig : GM 65 GTT
Drill hammer : Furukawa HB2G
Drill rod : Geostång Ø44
Drill bit : Stift Ø54

GEOLOGICAL LOG
0-0,2m silty topsoil
0,2-0,6m silty dry crust of clay
0,6-1,1m silty sand
1,1-7,8m sandy till
7,8m rock surface

ToSP : Top of Stand Pipe
m.a.g.l. : meters above ground level
m.b.g.l. : meters below ground level

LAXEMAR BOREHOLE SSM000224

Company rep.
Torbjörn Johansson

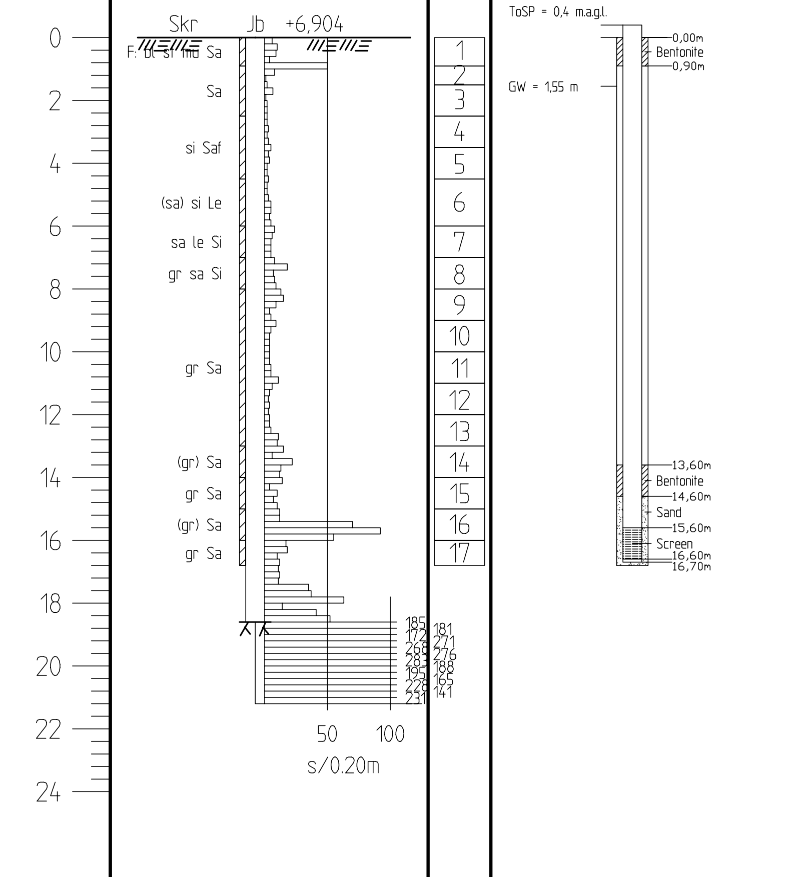
Client: Svensk Kärnbränslehantering AB

Northing :6368091,688
Easting :1548666,979

Coordinate system : RT90-RHB70

Top of stand pipe : 0,40 m.a.g.l.
Total pipe length : 17,10 m
Groundwater level : 1,55 m.b.g.l.
Date of completion : 2005-09-06

Depth (m)	Description	Samples	Groundwater monitoring well description	Borehole Construction Information



Drilling method : NOEK
Borehole diameter : 120 mm
sampling method : Auger

CASING
Material : PEH
Outer diameter : 63 mm
Inner diameter : 50 mm
Total length : 16,00 m

SCREEN
Material : PEH
Outer diameter : 63 mm
Inner diameter : 50 mm
Total length : 1,00 m
Slot : 0,3 mm

ANNULUS SEAL
Material : Bentonite clay
Total length : 1,90 m

SAND PACK
Grain size : 0,4-0,8 mm
Total length : 2,20 m

DRILLING EQUIPMENT
Drilling rig : GM 65 GTT
Drill hammer : Furukawa HB2G
Drill rod : Geostång Φ44
Drill bit : Stift Φ54

GEOLOGICAL LOG
0-0,9m Fill: boulder-, cobble- and humus-bearing sand
0,9-2,5m sand
2,5-4,5m silty fine sand
4,5-6,0m somewhat sandy silty clay
6,0-7,0m sandy clayey silt
7,0-8,0m gravelly sandy silt
8,0-13,0m gravelly sand
13,0-14,0m somewhat gravelly sand
14,0-15,0m gravelly sand
15,0-16,0m somewhat gravelly sand
16,0-16,8m gravelly sand

ToSP : Top of Stand Pipe
m.a.g.l. : meters above ground level
m.b.g.l. : meters below ground level

LAXEMAR BOREHOLE SSM000225

Company rep.
Torbjörn Johansson

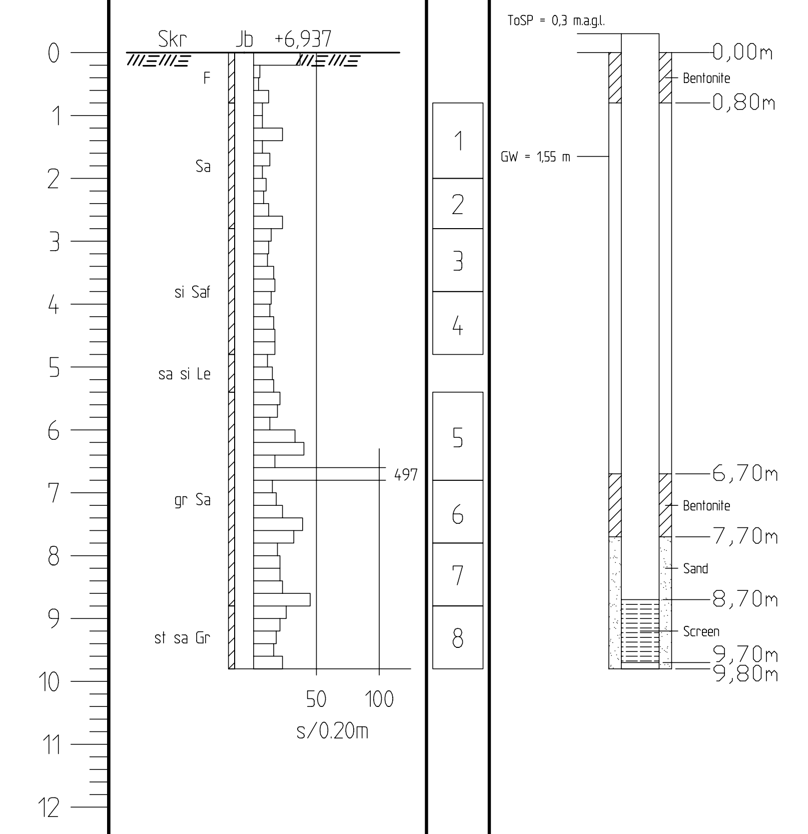
Client: Svensk Kärnbränslehantering AB

Northing :6368092,167
Easting :1548669,442

Coordinate system : RT90-RHB70

Top of stand pipe : 0,3 m.a.g.l.
Total pipe length : 10,10 m
Groundwater level : 1,55 m.b.g.l.
Date of completion : 2005-09-06

Depth (m)	Description	Samples	Groundwater monitoring well description	Borehole Construction Information



Drilling method : NOEK
Borehole diameter : 120 mm
sampling method : Auger

CASING
Material : PEH
Outer diameter : 63 mm
Inner diameter : 50 mm
Total length : 9,00 m

SCREEN
Material : PEH
Outer diameter : 63 mm
Inner diameter : 50 mm
Total length : 1,00 m
Slot : 0,3 mm

ANNULUS SEAL
Material : Bentonite clay
Total length : 1,80 m

SAND PACK
Grain size : 0,4-0,8 mm
Total length : 2,10 m

DRILLING EQUIPMENT
Drilling rig : GM 65 GTT
Drill hammer : Furukawa HB2G
Drill rod : Geostång Φ44
Drill bit : Stift Φ54

GEOLOGICAL LOG
0-0,8m Fill
0,8-2,8m sand
2,8-4,8m silty fine sand
4,8-5,4m sandy silty clay
5,4-8,8m gravelly sand
8,8-9,8m cobble-bearing sandy gravel

ToSP : Top of Stand Pipe
m.a.g.l. : meters above ground level
m.b.g.l. : meters below ground level

LAXEMAR BOREHOLE SSM000226

Company rep.
Torbjörn Johansson

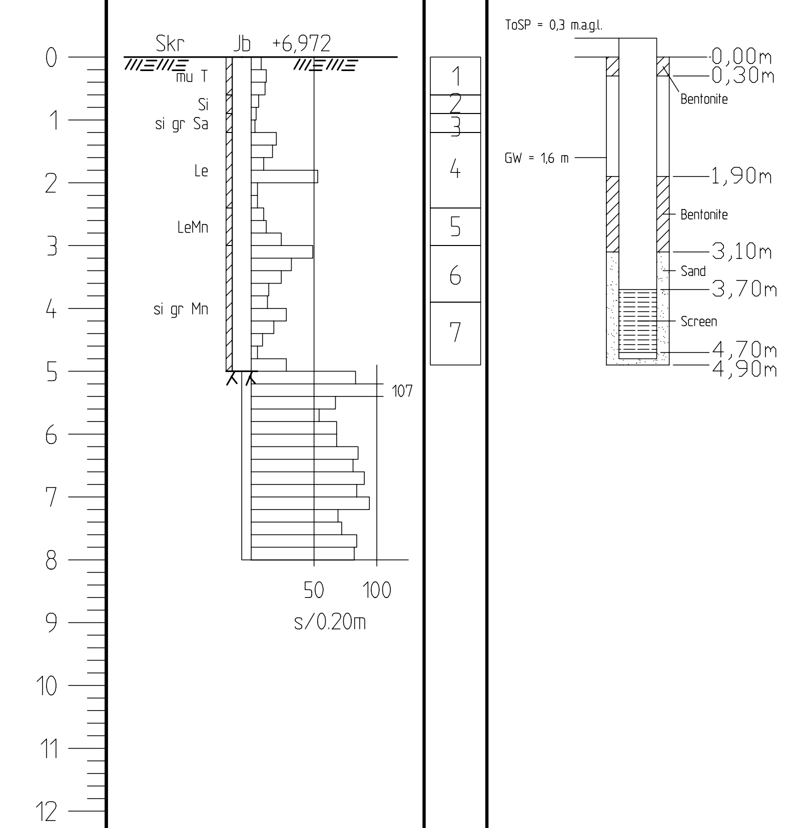
Client: Svensk Kärnbränslehantering AB

Northing :6367696,292
Easting :1549790,186

Coordinate system : RT90-RHB70

Top of stand pipe : 0,3 m.a.g.l.
Total pipe length : 5,10 m
Groundwater level : 1,6 m.b.g.l.
Date of completion : 2005-09-14

Depth (m)	Description	Samples	Groundwater monitoring well description	Borehole Construction Information



Drilling method : NOEK
Borehole diameter : 120 mm
sampling method : Auger

CASING
Material : PEH
Outer diameter : 63 mm
Inner diameter : 50 mm
Total length : 4,00 m

SCREEN
Material : PEH
Outer diameter : 63 mm
Inner diameter : 50 mm
Total length : 1,00 m
Slot : 0,3 mm

ANNULUS SEAL
Material : Bentonite clay
Total length : 1,50 m

SAND PACK
Grain size : 0,4-0,8 mm
Total length : 1,80 m

DRILLING EQUIPMENT
Drilling rig : GM 65 GTT
Drill hammer : Furukawa HB2G
Drill rod : Geostång Ø44
Drill bit : Stift Ø54

GEOLOGICAL LOG
0-0,6 m humus-bearing peat
0,6-0,9m silt
0,9-1,2m silty gravelly sand
1,2-2,4m clay
2,4-3,0m clay till
3,0-5,0m silty gravelly till
5,0m rock surface

ToSP : Top of Stand Pipe
m.a.g.l. : meters above ground level
m.b.g.l. : meters below ground level

LAXEMAR BOREHOLE SSM000227

Company rep.
Torbjörn Johansson

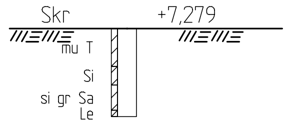
Client: Svensk Kärnbränslehantering AB

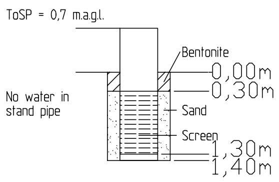
Northing :6367693,239
Easting :1549787,713

Coordinate system : RT90-RHB70

Top of stand pipe : 0,7 m.a.g.l.
Total pipe length : 2,10 m
Groundwater level : -
Date of completion : 2005-09-14

Depth (m)	Description	Samples	Groundwater monitoring well description	Borehole Construction Information
0–12	Skr +7,279; mu T; Si; si gr Sa; Le	1	ToSP = 0,7 m.a.g.l.; No water in stand pipe; Bentonite 0,00m, 0,30m; Sand; Screen 1,30m, 1,40m	see below





Drilling method : Auger
Borehole diameter : 82 mm
sampling method : Auger

CASING
Material : PEH
Outer diameter : 63 mm
Inner diameter : 50 mm
Total length : 1,00 m

SCREEN
Material : PEH
Outer diameter : 63 mm
Inner diameter : 50 mm
Total length : 1,00 m
Slot : 0,3 mm

ANNULUS SEAL
Material : Bentonite clay
Total length : 0,30m

SAND PACK
Grain size : 0,4-0,8 mm
Total length : 1,10 m

DRILLING EQUIPMENT
Drilling rig : GM 65 GTT
Drill hammer : Furukawa HB2G
Drill rod : Geostång Φ44
Drill bit : Stift Φ54

GEOLOGICAL LOG
0-0,6m humus-bearing peat
0,6-0,9m silt
0,9-1,3m silty gravelly sand
1,3-1,4m clay

ToSP : Top of Stand Pipe
m.a.g.l. : meters above ground level
m.b.g.l. : meters below ground level

LAXEMAR BOREHOLE SSM000228

Company rep.
Torbjörn Johansson

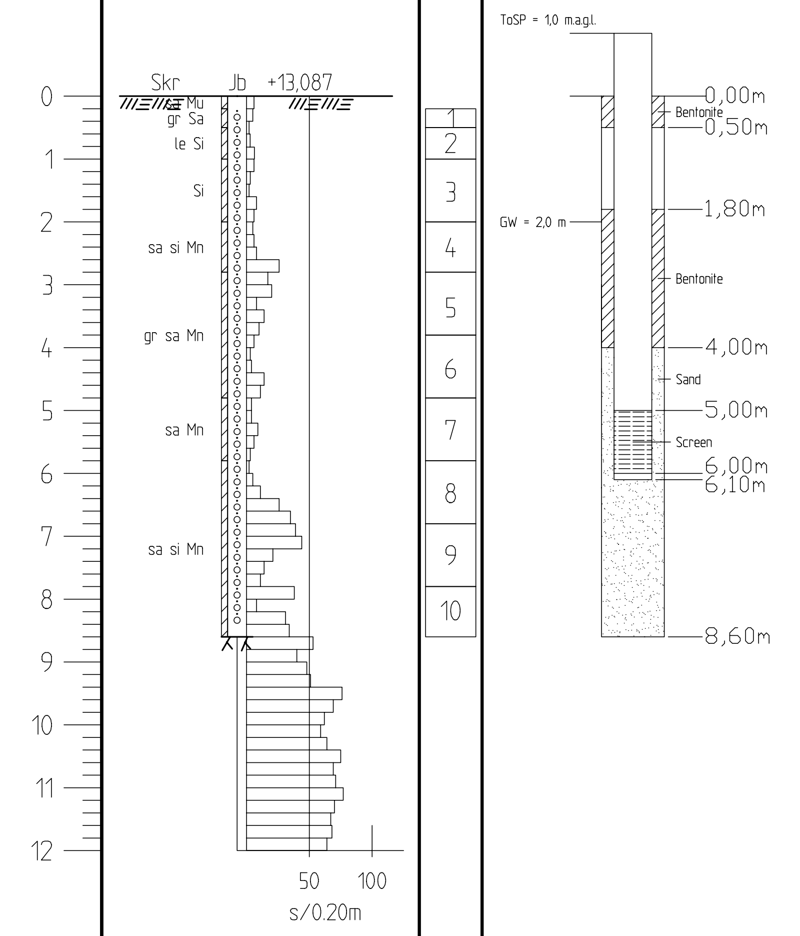
Client: Svensk Kärnbränslehantering AB

Northing :6366503,701
Easting :1548718,363

Coordinate system : RT90-RHB70

Top of stand pipe : 1,0 m.a.g.l.
Total pipe length : 7,10 m
Groundwater level : 2,0 m.b.g.l.
Date of completion : 2005-09-19

Depth (m)	Description	Samples	Groundwater monitoring well description	Borehole Construction Information



Drilling method : NOEK
Borehole diameter : 120 mm
sampling method : Auger

CASING
Material : PEH
Outer diameter : 63 mm
Inner diameter : 50 mm
Total length : 6,00 m

SCREEN
Material : PEH
Outer diameter : 63 mm
Inner diameter : 50 mm
Total length : 1,00 m
Slot : 0,3 mm

ANNULUS SEAL
Material : Bentonite clay
Total length : 2,70 m

SAND PACK
Grain size : 0,4-0,8 mm
Total length : 4,60 m

DRILLING EQUIPMENT
Drilling rig : GM 65 GTT
Drill hammer : Furukawa HB2G
Drill rod : Geostång Ø44
Drill bit : Stift Ø54

GEOLOGICAL LOG
0-0,2m sandy topsoil
0,2-0,5m gravelly sand
0,5-1,0m clayey silt
1,0-2,0m silt
2,0-2,8m sandy silty till
2,8-4,8m gravelly sandy till
4,8-5,8m sandy till
5,8-8,6m sandy silty till
8,6m rock surface

ToSP : Top of Stand Pipe
m.a.g.l. : meters above ground level
m.b.g.l. : meters below ground level

LAXEMAR BOREHOLE SSM000229

Company rep.
Torbjörn Johansson

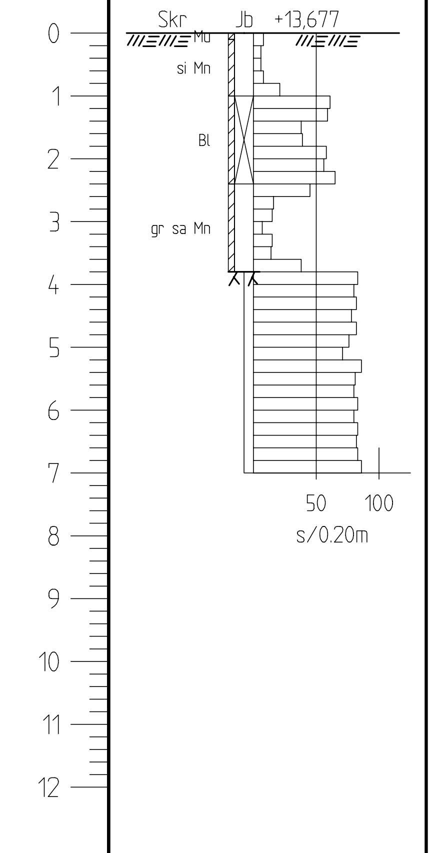
Client: Svensk Kärnbränslehantering AB

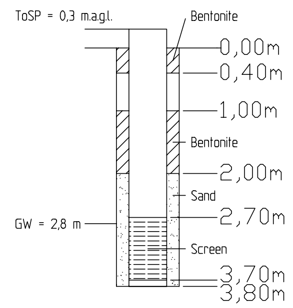
Northing :6366475,650
Easting :1548721,342

Coordinate system : RT90-RHB70

Top of stand pipe : 0,3 m.a.g.l.
Total pipe length : 4,10 m
Groundwater level : 2,8 m.b.g.l.
Date of completion : 2005-09-20

Depth (m)	Description	Samples	Groundwater monitoring well description	Borehole Construction Information





Drilling method : NOEK
Borehole diameter : 120 mm
sampling method : Auger

CASING
Material : PEH
Outer diameter : 63 mm
Inner diameter : 50 mm
Total length : 3,00 m

SCREEN
Material : PEH
Outer diameter : 63 mm
Inner diameter : 50 mm
Total length : 1,00 m
Slot : 0,3 mm

ANNULUS SEAL
Material : Bentonite clay
Total length : 1,40 m

SAND PACK
Grain size : 0,4-0,8 mm
Total length : 1,80 m

DRILLING EQUIPMENT
Drilling rig : GM 65 GTT
Drill hammer : Furukawa HB2G
Drill rod : Geostång Φ44
Drill bit : Stift Φ54

GEOLOGICAL LOG
0-0,1m topsoil
0,1-1,0m silty till
1,0-2,4m boulders
2,4-3,8m gravelly sandy till
3,8m rock surface

ToSP : Top of Stand Pipe
m.a.g.l. : meters above ground level
m.b.g.l. : meters below ground level

LAXEMAR BOREHOLE SSM000230

Company rep.
Torbjörn Johansson

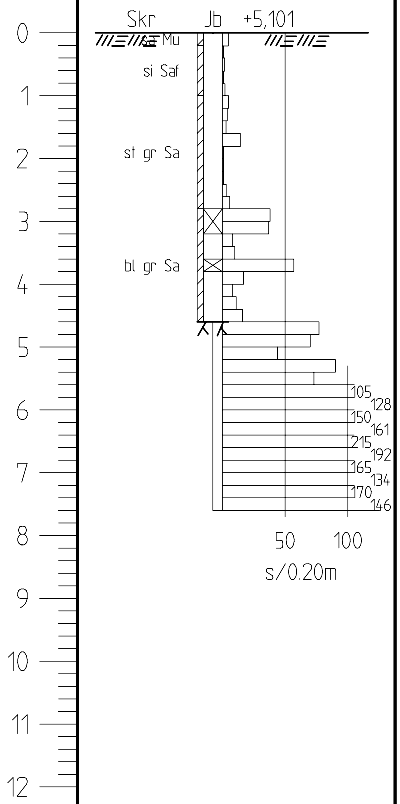
Client: Svensk Kärnbränslehantering AB

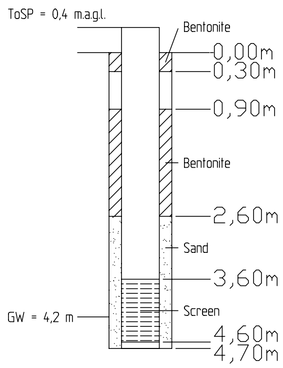
Northing :6366219,918
Easting :1550069,106

Coordinate system : RT90-RHB70

Top of stand pipe : 0,4 m.a.g.l.
Total pipe length : 5,10 m
Groundwater level : 4,2 m.b.g.l.
Date of completion : 2005-09-21

Depth (m)	Description	Samples	Groundwater monitoring well description	Borehole Construction Information





Drilling method : NOEK
Borehole diameter : 120 mm
sampling method : Auger

CASING
Material : PEH
Outer diameter : 63 mm
Inner diameter : 50 mm
Total length : 4,00 m

SCREEN
Material : PEH
Outer diameter : 63 mm
Inner diameter : 50 mm
Total length : 1,00 m
Slot : 0,3 mm

ANNULUS SEAL
Material : Bentonite clay
Total length : 2,00 m

SAND PACK
Grain size : 0,4-0,8 mm
Total length : 2,10 m

DRILLING EQUIPMENT
Drilling rig : GM 65 GTT
Drill hammer : Furukawa HB2G
Drill rod : Geostång Ø44
Drill bit : Stift Ø54

GEOLOGICAL LOG
0-0,2m sandy topsoil
0,2-1,0m silty fine sand
1,0-2,8m cobble-bearing gravelly sand
2,8-4,6m boulder-bearing gravelly sand
4,6m rock surface

ToSP : Top of Stand Pipe
m.a.g.l. : meters above ground level
m.b.g.l. : meters below ground level

Photos of the borehole sites after completion of work

Borehole SSM000222

Borehole SSM000223

Borehole SSM000224 (nearest) and SSM000225

Borehole SSM000226 (nearest) and SSM000227

Borehole SSM000228

Borehole SSM000229

Borehole SSM000230

Appendix 4

Vegetation conditions at the four profiles

Vegetation			
Profile 1	**Profile 3**	**Profile 4**	**Profile 5**
Bottom layer species			
Cladiona alpestris			
Hypnum cupressiforme			
Pleurozium Schreberi	*Pleurozium Schreberi*	*Pleurozium Schreberi*	*Pleurozium Schreberi*
Rhytidiadelphus squarrosus		*Rhytidiadelphus squarrosus*	*Rhytidiadelphus squarrosus*
Field layer species			
Achillea Millefolium	*Cynosurus cristatus*	*Achillea Millefolium*	*Achillea Millefolium*
Agropyron repens	*Galeopsis Tetrahit*	*Cirsium palustre*	*Agropyron repens*
Anthriscus silvetris	*Juncus effusus*	*Daucus Carota*	*Alisma Plantago-aquatica*
Campanula persicifolia	*Lactuca muralis*	*Fragaria vesca*	*Bidens tripartita*
Campanula spp.	*Poa nemoralis*	*Lathyrus pratensis*	*Cirsium acaule*
Cirsium arvense	*Senecio viscosus*	*Lotus corniculatus*	*Cirsium arvense*
Crepis praemorsa	*Triglochin palustre(?)*	*Melampyrum pratense*	*Crepis praemorsa*
Dactylis glomerata	*Urtica dioica*	*Phalaris arundinaccea*	*Epilobium palustre*
Daucus Carota	*Vaccinium Myrtillus*	*Poa pratensis*	*Equisetum palustre*
Epilobium spp.		*Prunella vulgaris*	*Galium palustre*
Fragaria vesca		*Rumex Acetosella*	*Lolium spp.*
Galium Mollugo		*Trifolium medium*	*Lusimachia thyrsilflora*
Galium verum		*Trifolium pratense*	*Matricaria inodora*
Geum urbanum		*Vicia Cracca*	*Phleum pratense*
Hypericum spp.			*Plantago major*
Knautia arvensis			*Poa annua*
Lathyrus pratensis			*Polygonum aviculare*
Lotus corniculatus			*Prunella vulgaris*
Luzula pilosa			*Ranunculus repens*
Matteuccia struthiopteris			*Rumex domesticus*
Phleum pratense			*Scutellaria galericulata*
Poa pratensis			*Senecio viscosus*
Potentilla erecta			*Stellaria aquatica*
Ranunculus acris			*Taraxacum vulgare*
Rumex domesticus			*Trifolium hybridum*
Taraxacum vulgare			*Trifolium pratense*
Trifolium medium			*Trifolium repens*
Trifolium pratense			*Urtica dioica*
Urtica dioica			
Vaccinium Vitis-idaea			
Vicia Cracca			
Vulgata			
Tree-bush species			
Acer platanoides	*Betula spp.*	*Acer platanoides*	*Rubus idaeus*
Betula spp.	*Picea Abies*	*Betula spp.*	
Corylus Avellana	*Rubus idaeus*	*Picea Abies*	
Picea Abies	*Sorbus aucuparia*	*Pinus silvestris*	
Pinus silvestris		*Populus tremula*	
Quercus Robur		*Quercus Robur*	
Rosa canina			
Rubus idaeus			
Salix caprea			

PSM007160, 0.7–0.8 m, Gyttja clay

Kornfördelning
enl. SS027123 och SS027124

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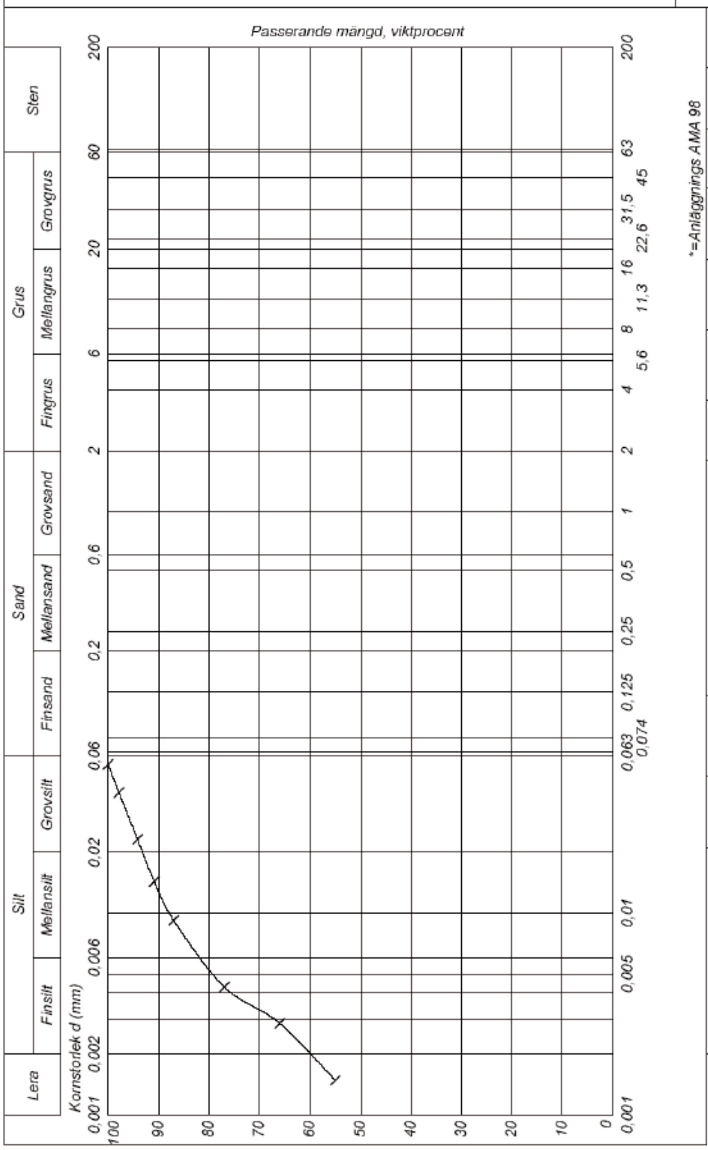
Projekt: **Prov nr 28200-28219**		*Datum:*	2005-10-28
Uppdragsnr: 40092	*Provtagningsdatum:* 2005-08-16	*Löp-nr:*	14436
Uppdragsgivare: SGU, Uppsala		*Gransk./Sign:*	



*=Anläggnings AMA 98

Sektion Borrhål	Prov-beteckning	Djup (m)	Gäller mellan (m)	Benämning	Siktat Prov (g)	Glödgn.-förlust %	Mtrl % > mm	Tjäl-farlighet	d10	d60	d90
PSM 007160 28200	——✕——		0,7-0,8	Gyttjelera (SGU serie Ae)		2,5		5B/4*		0,002	0,013

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SWECO

1(1)

PSM007160, 1.0–1.1, Gravelly sand

Kornfördelning
enl. SS027123 och SS027124

SWECO GEOLAB

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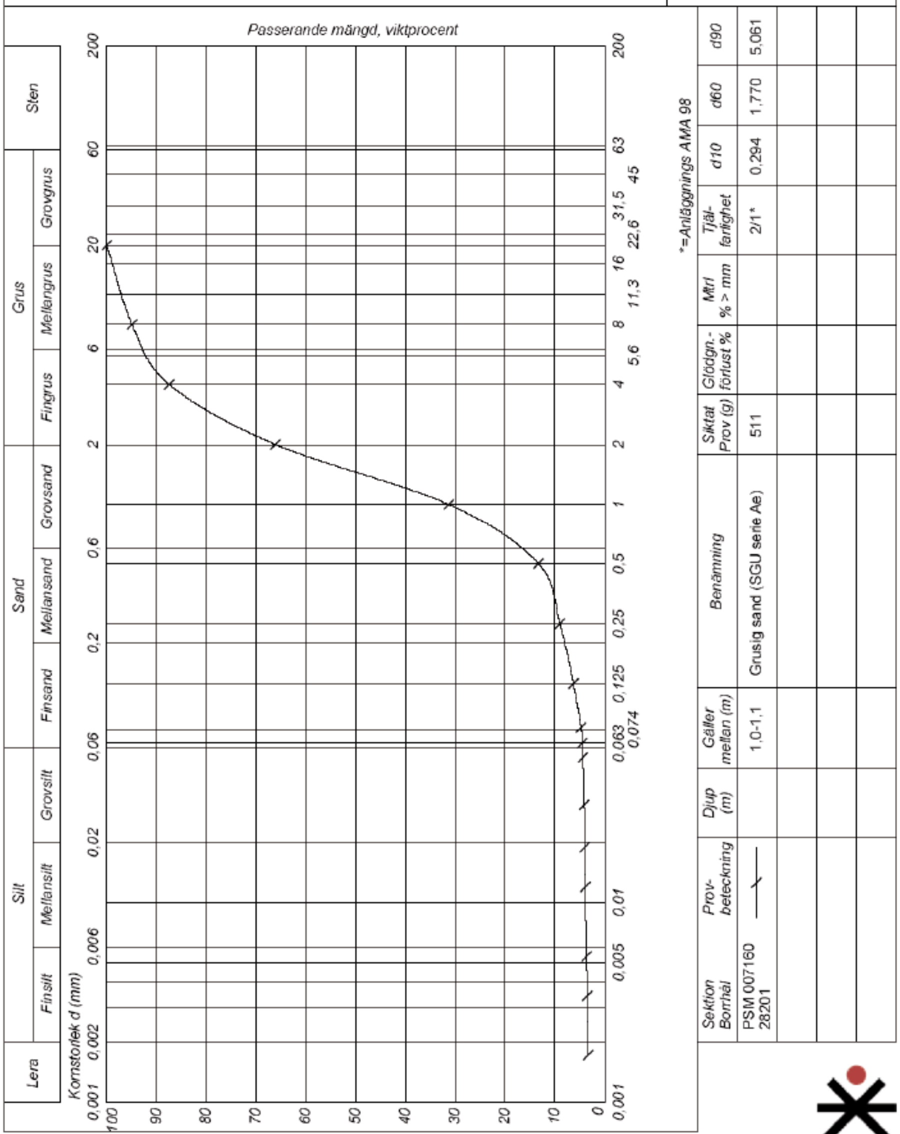
Uppdragsnr: 40092	*Provtagningsdatum:* 2005-08-16	*Löp-nr:* 14436
Uppdragsgivare: SGU, Uppsala		*Gransk./Sign:*



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1(1)

PSM007160, 1.25–1.3m, Heavy clay

Kornfördelning
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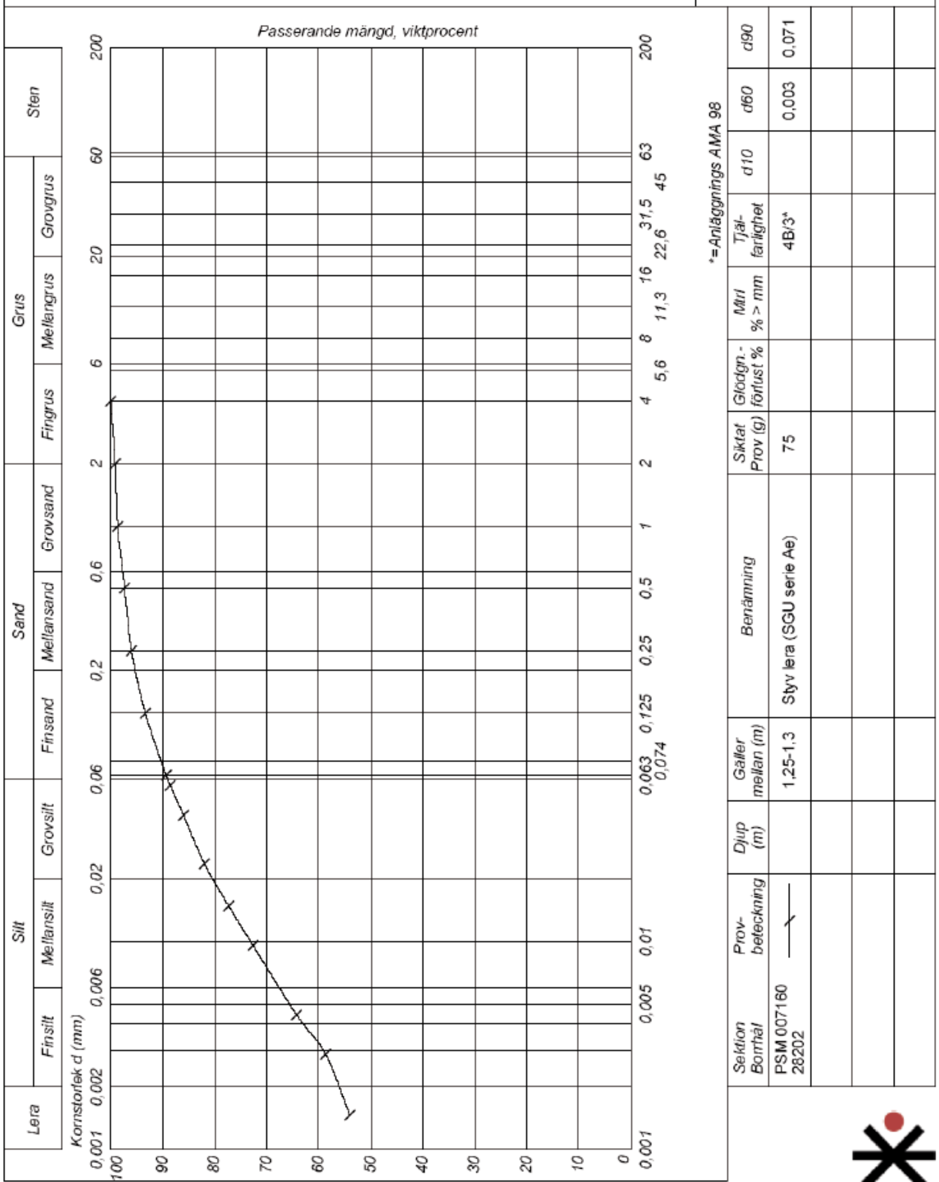
Uppdragsgivare: SGU, Uppsala		*Gransk./Sign:*	



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1(1)

PSM007160, 2.2 m, Gravelly till

Kornfördelning
enl. SS027123 och SS027124

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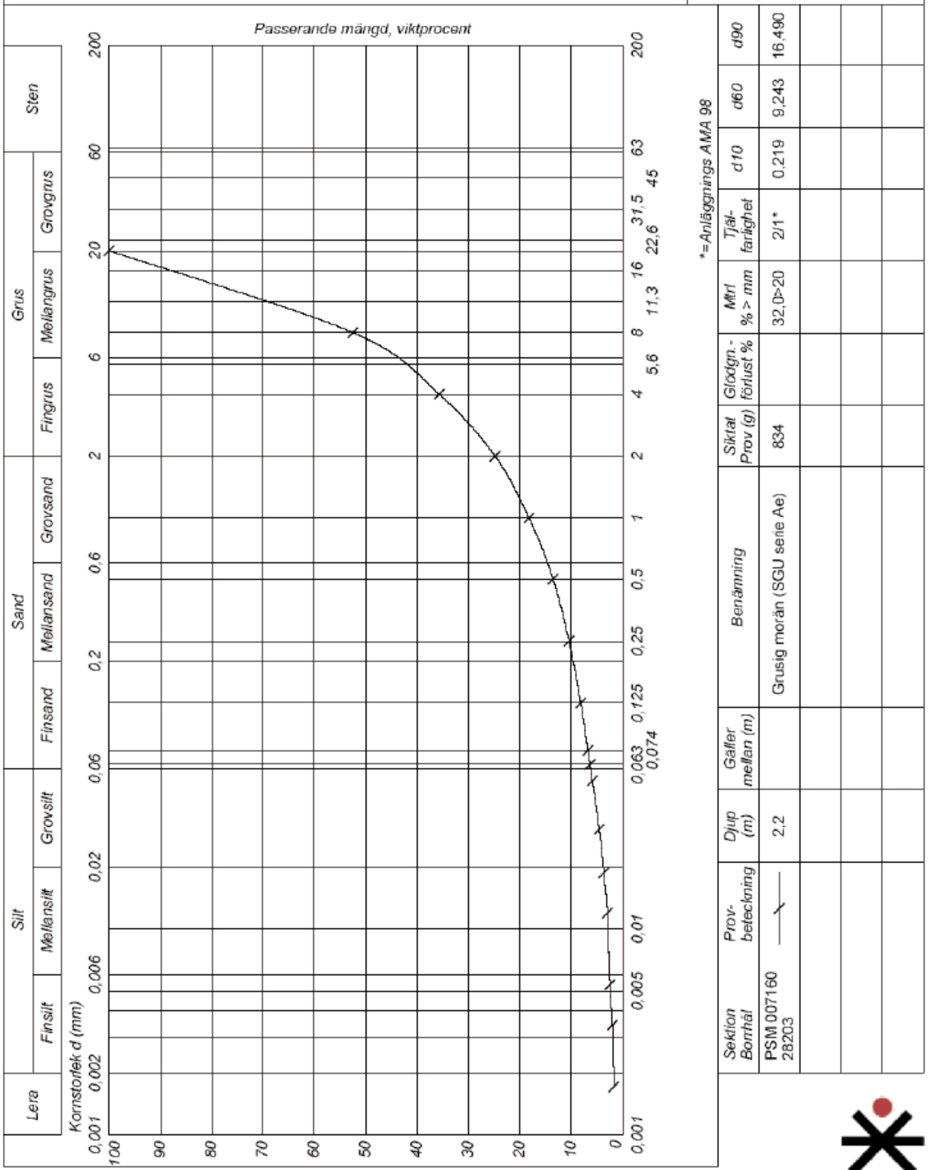
Uppdragsnr: 40092	*Provtagningsdatum:* 2005-08-17	*Löp-nr:*	14436
Uppdragsgivare: SGU, Uppsala		*Gransk./Sign:*	



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SWECO

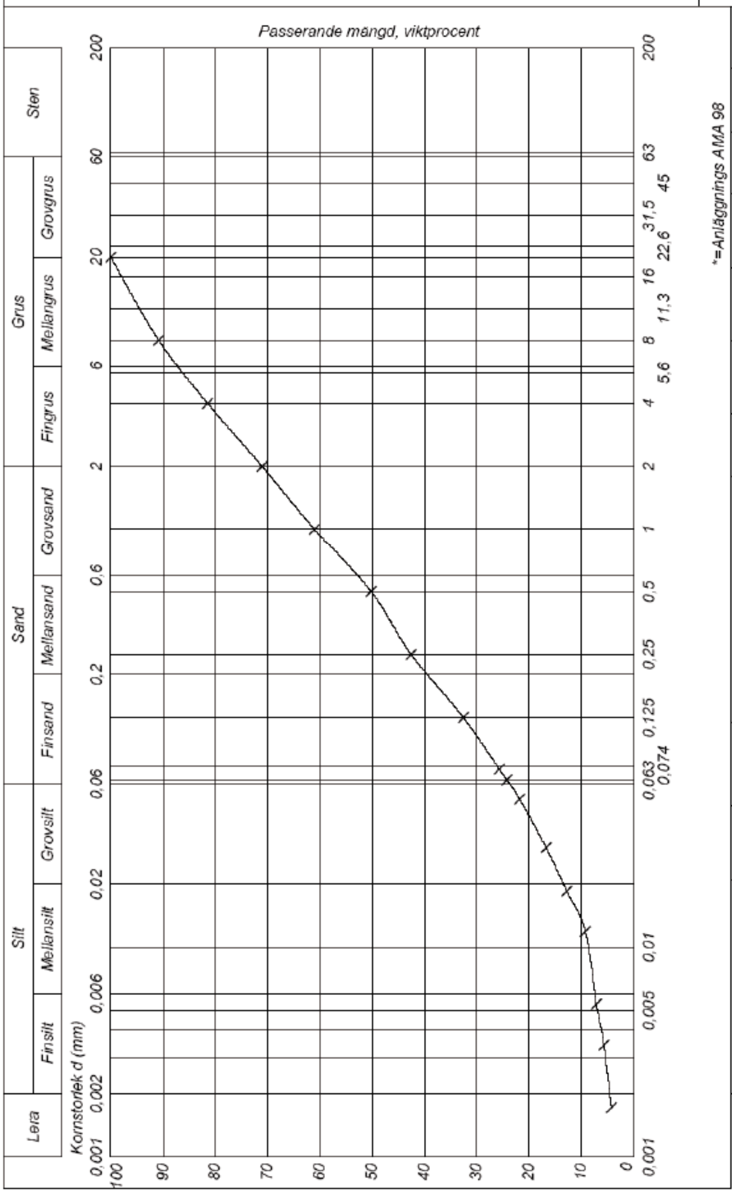
1(1)

PSM007162, 1.0–1.1 m, Sandy till

Kornfördelning
enl. SS027123 och SS027124

SWECO GEOLAB

Projekt: **Prov nr 28200-28219**	*Datum:* 2005-10-28
Uppdragsnr: 40092 *Provtagningsdatum:* 2005-08-17	*Löp-nr:* 14436
Uppdragsgivare: SGU, Uppsala	*Gransk./Sign:*



*=Anläggnings AMA 98

Sektion Borrhål	Prov-beteckning	Djup (m)	Gäller mellan (m)	Benämning	Siktat Prov (g)	Glödgn.-förlust %	Mtrl % > mm	Tjäl-farlighet	d10	d60	d90
PSM 007162 28204	——+——		1,0-1,1	Sandig morän (SGU serie Ae)	470		21,0>20	3B/2*	0,013	0,934	7,511

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1(1)

PSM007163, 1.0 m, Gravelly till

Kornfördelning
enl. SS027123 och SS027124

SWECO GEOLAB

Projekt: **Prov nr 28200-28219**	*Datum:* 2005-10-28
Uppdragsnr: 40092 *Provtagningsdatum:* 2005-08-17	*Löp-nr:* 14436
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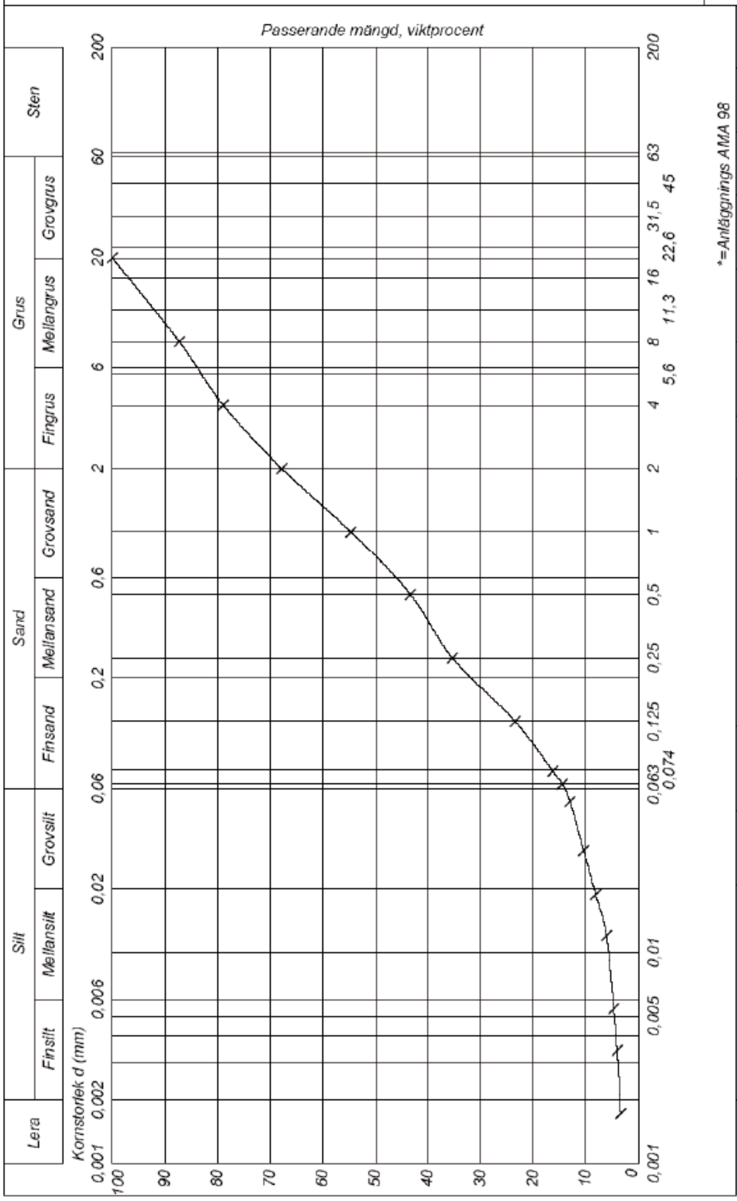

*=Anläggnings AMA 98

d90	9,734
d60	1,325
d10	0,028
Tjäl-farlighet	2/1*
Mtrl % > mm	15,0>20
Glödgn.-förlust %	
Siktat Prov (g)	503
Benämning	Grusig morän (SGU serie Ae)
Gäller mellan (m)	
Djup (m)	1,0
Prov-beteckning	——+——
Sektion Borrhål	PSM 007163 28205

PSM007170, 1.2 m

Kornfördelning
enl. SS027123 och SS027124

SWECO GEOLAB

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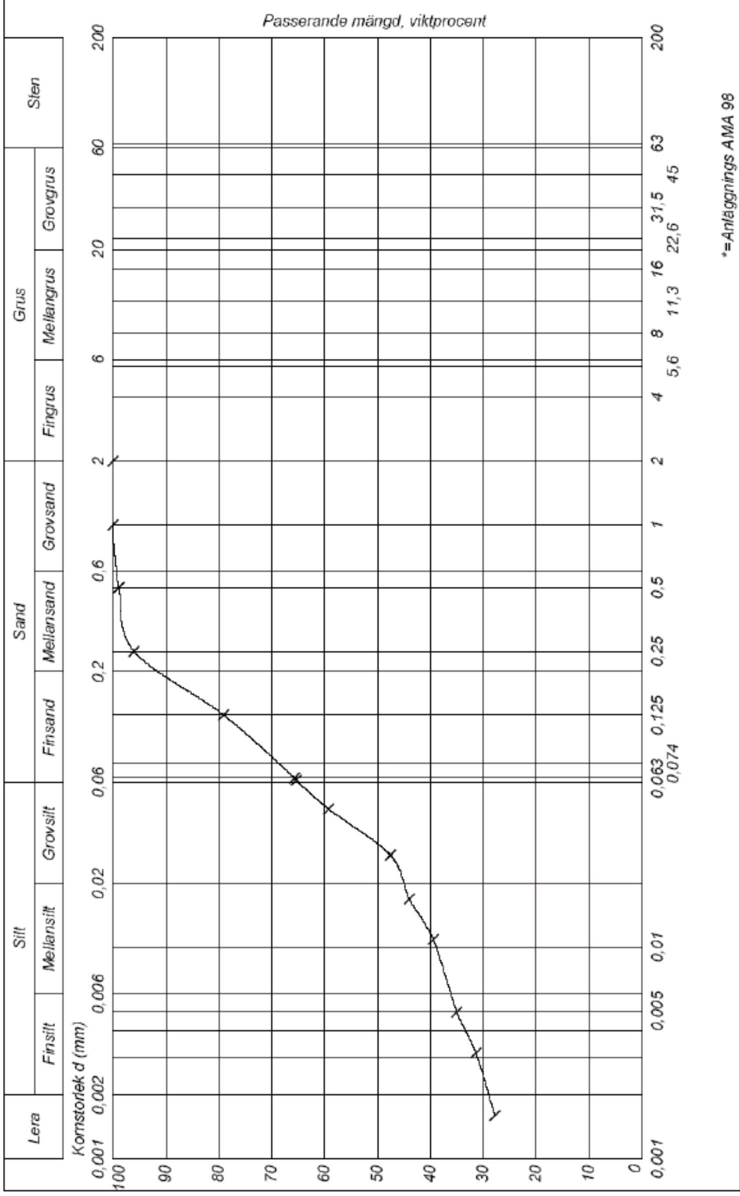
Uppdragsgivare: SGU, Uppsala		*Gransk./Sign:*	



*=Anläggnings AMA 98

d90	0,195
d60	0,047
d10	
Tjäl-farlighet	4B/3*
Mtrl % > mm	
Glödgn.-förlust %	
Siktat Prov (g)	67
Benämning	Mellanlera (SGU serie Ae)
Gäller mellan (m)	
Djup (m)	1,2
Prov-beteckning	—×—
Sektion Borrhål	PSM 007170 28206

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SWECO

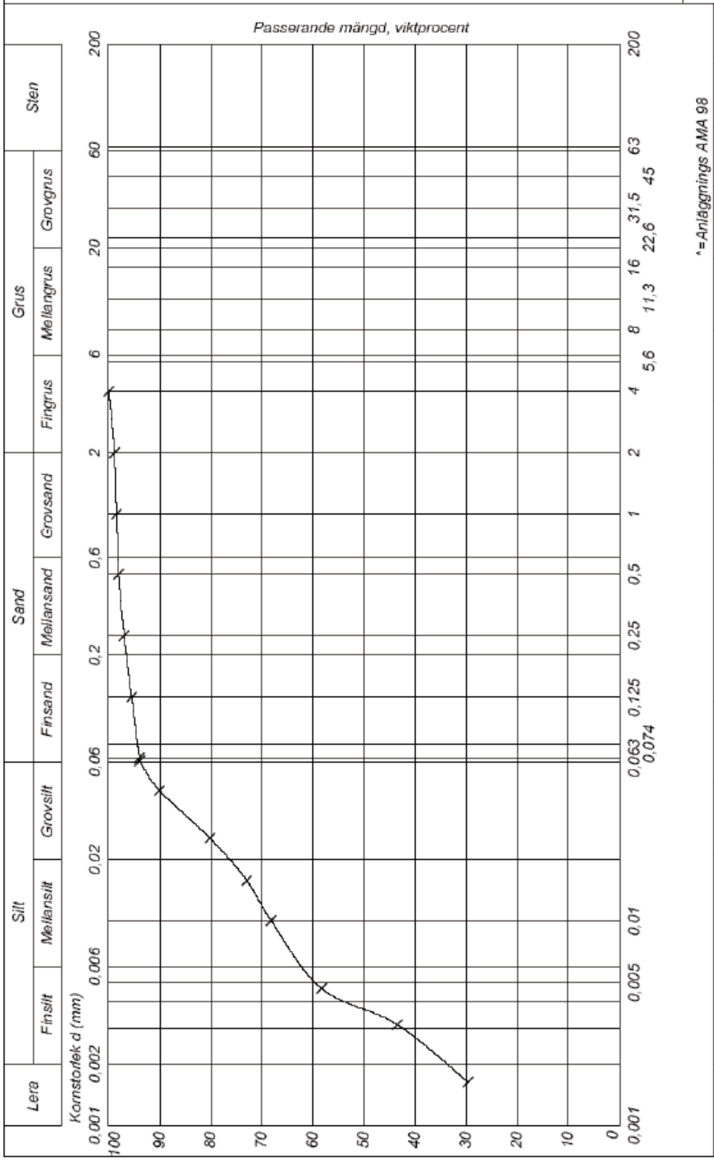
1(1)

PSM007171, 0.5 m, Clay gyttja

Kornfördelning
enl. SS027123 och SS027124

SWECO GEOLAB

Projekt:	**Prov nr 28200-28219**	*Datum:*	2005-10-28
Uppdragsnr: 40092	*Provtagningsdatum:* 2005-08-22	*Löp-nr:*	14436
Uppdragsgivare: SGU, Uppsala		*Gransk./Sign:*	



*=Anläggnings AMA 98

d90	0,043
d60	0,005
d10	
Tjäl-farlighet	6A/4*
Mtrl % > mm	
Glödgn.-förlust %	7,9
Siktat Prov (g)	67
Benämning	Lergyttja (SGU serie Ae)
Gäller mellan (m)	
Djup (m)	0,5
Prov-beteckning	—×—
Sektion Borrhål	PSM007171 28207

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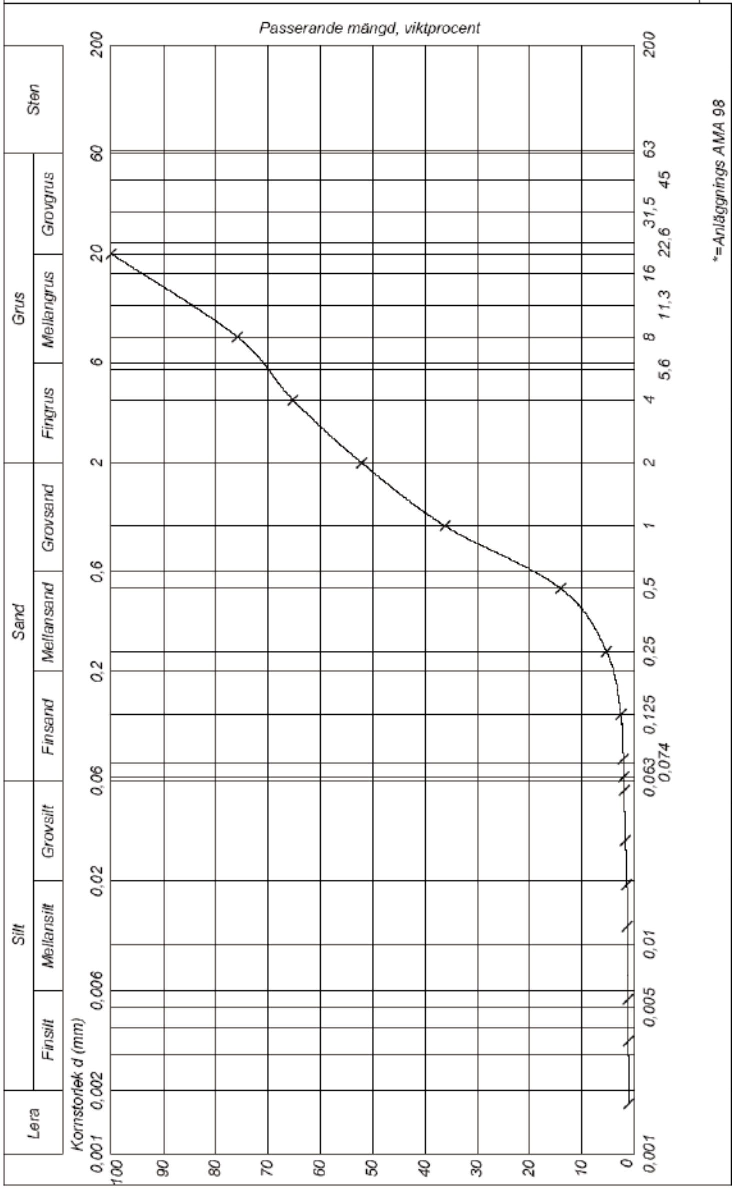
1(1)

PSM007171, 1.25 m, Gravelly sand

Kornfördelning
enl. SS027123 och SS027124

SWECO GEOLAB

Projekt: **Prov nr 28200-28219**	*Datum:* 2005-10-28
Uppdragsnr: 40092 — *Provtagningsdatum:* 2005-08-22	*Löp-nr:* 14436
Uppdragsgivare: SGU, Uppsala	*Gransk./Sign:*



*=Anläggnings AMA 98

Sektion Borrhål	Prov-beteckning	Djup (m)	Galler mellan (m)	Benämning	Siktat Prov (g)	Glödgn.-förlust %	Mtrl % > mm	Tjäl-farlighet	d10	d60	d90
PSM 007171 28208	—+—	1,25		Grusig sand (SGU serie Ae)	547		30,0>20	2/1*	0,362	3,031	13,681

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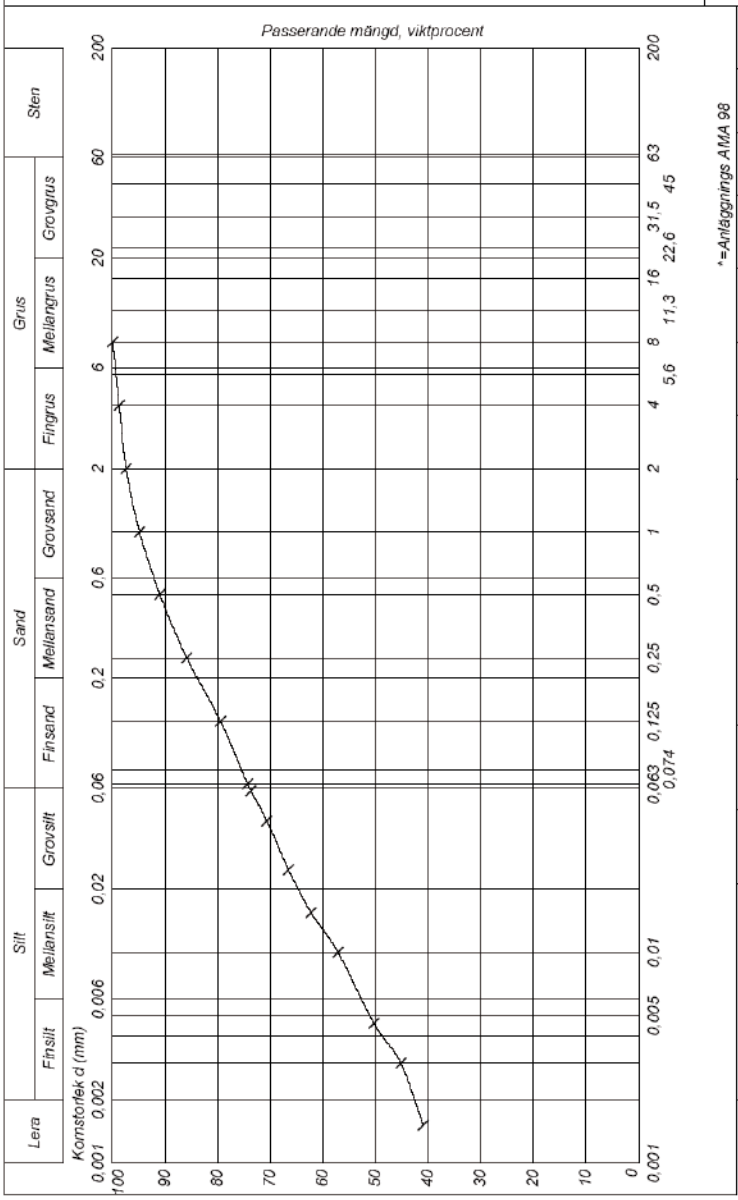
1(1)

PSM007171, 1.4 m, Heavy clay

Kornfördelning
enl. SS027123 och SS027124

SWECO GEOLAB

Projekt: **Prov nr 28200-28219**		*Datum:* 2005-10-28
Uppdragsnr: 40092	*Provtagningsdatum:* 2005-08-22	*Löp-nr:* 14436
Uppdragsgivare: SGU, Uppsala		*Gransk./Sign:*



*=Anläggnings AMA 98

Sektion Borrhål	Prov-beteckning	Djup (m)	Gäller mellan (m)	Benämning	Siktat Prov (g)	Glödgn.-förlust %	Mtrl % > mm	Tjäl-farlighet	d10	d60	d90
PSM 007171 28209	—×—	1,4		Styv lera (SGU serie Ae)	78			4B/3*		0,013	0,435

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SWECO

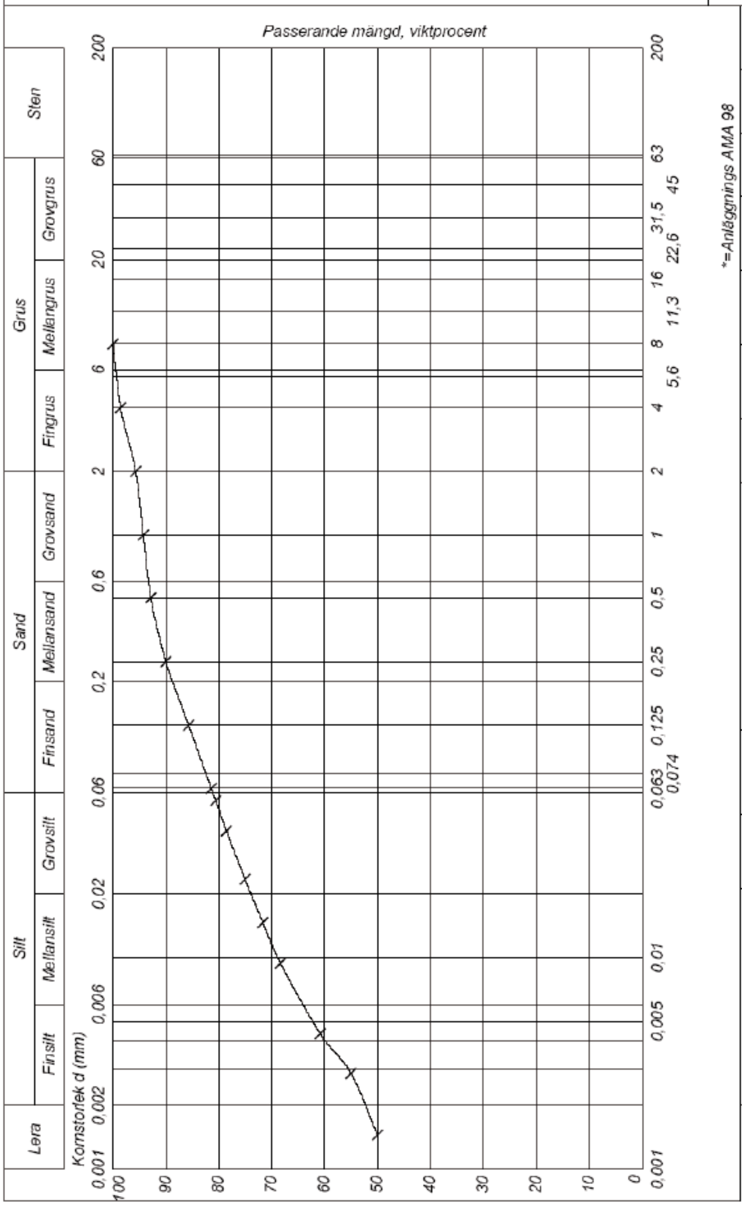
1(1)

PSM007171, 1.8 m, Heavy clay

Kornfördelning
enl. SS027123 och SS027124

SWECO GEOLAB

Projekt: **Prov nr 28200-28219**		*Datum:*	2005-10-28
Uppdragsnr: 40092	*Provtagningsdatum:* 2005-08-22	*Löp-nr:*	14436
Uppdragsgivare: SGU, Uppsala		*Gransk./Sign:*	



*=Anläggnings AMA 98

Sektion Borrhål	Prov-beteckning	Djup (m)	Gäller mellan (m)	Benämning	Siktat Prov (g)	Glödgn.-förlust %	Mtrl % > mm	Tjäl-farlighet	d10	d60	d90
PSM 007171 28210	—×—	1,8		Styv lera (SGU serie Ae)	70			4B/3*		0,004	0,250

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SWECO

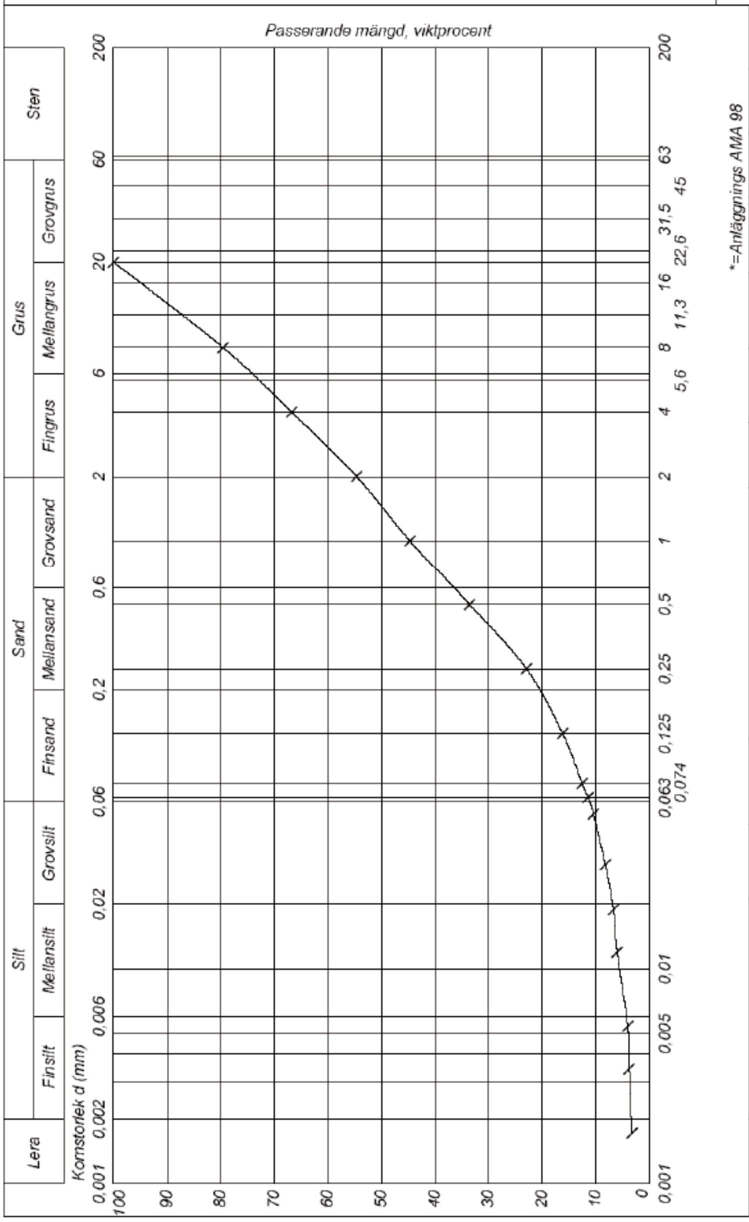
1(1)

PSM007171, 3.2 m, Gravelly till

Kornfördelning
enl. SS027123 och SS027124

SWECO GEOLAB

Projekt: **Prov nr 28200-28219**	*Datum:* 2005-10-28
Uppdragsnr: 40092 *Provtagningsdatum:* 2005-08-20	*Löp-nr:* 14436
Uppdragsgivare: SGU, Uppsala	*Gransk./Sign:*



*=Anläggnings AMA 98

d90	d60	d10	Tjäl-farlighet	Mtrl % > mm	Glödgn.-förlust %	Siktat Prov (g)	Benämning	Gäller mellan (m)	Djup (m)	Prov-beteckning	Sektion Borrhål
12,765	2,716	0,047	2/1*	13,0>20		593	Grusig morän (SGU serie Ae)		3,2	—×—	PSM 007171 28211

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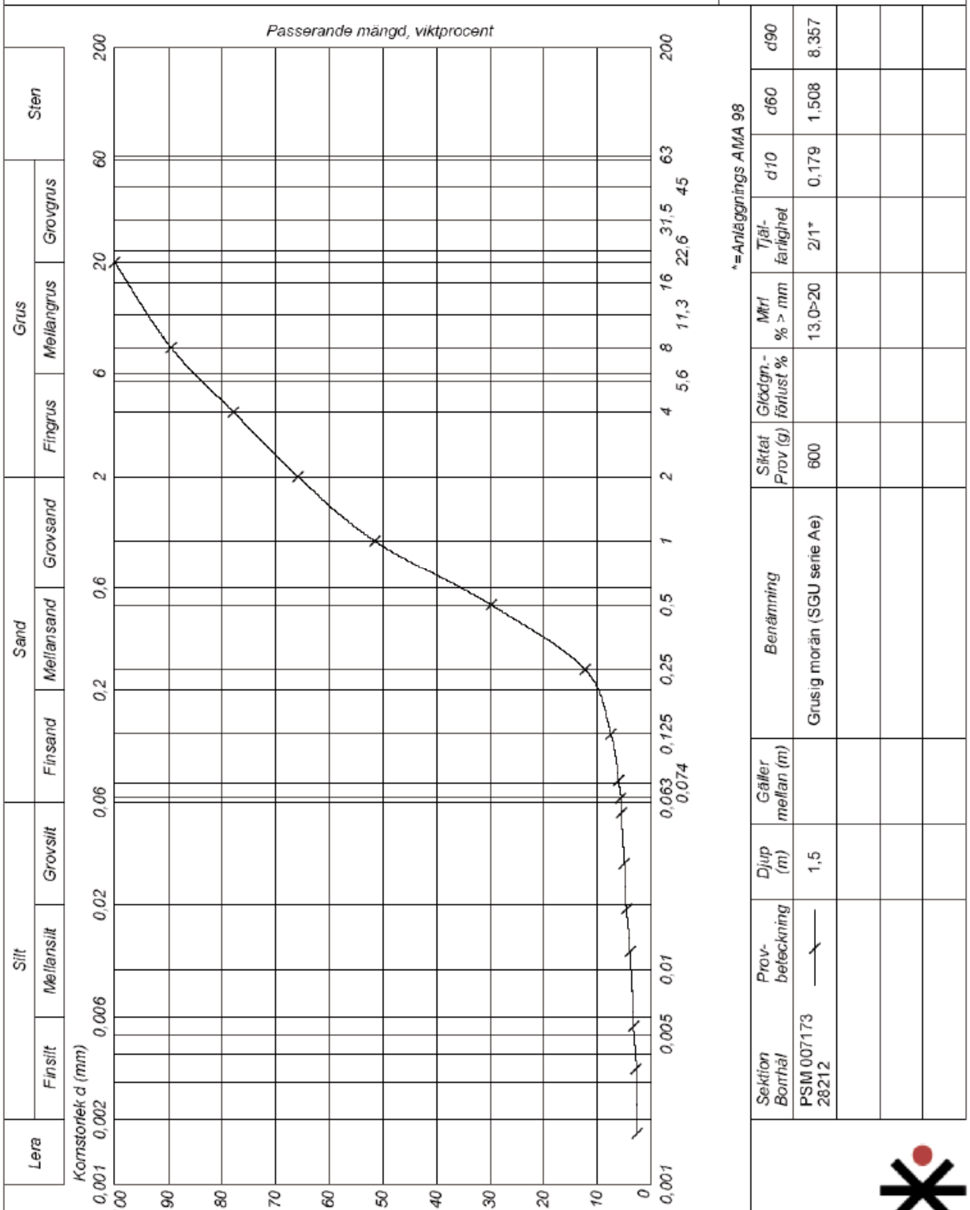
1(1)

PSM007173, 1.5 m, Gravelly till

Kornfördelning
enl. SS027123 och SS027124

SWECO GEOLAB

Projekt: **Prov nr 28200-28219**	*Datum:* 2005-10-28
Uppdragsnr: 40092 *Provtagningsdatum:* 2005-08-24	*Löp-nr:* 14436
Uppdragsgivare: SGU, Uppsala	*Gransk./Sign:*



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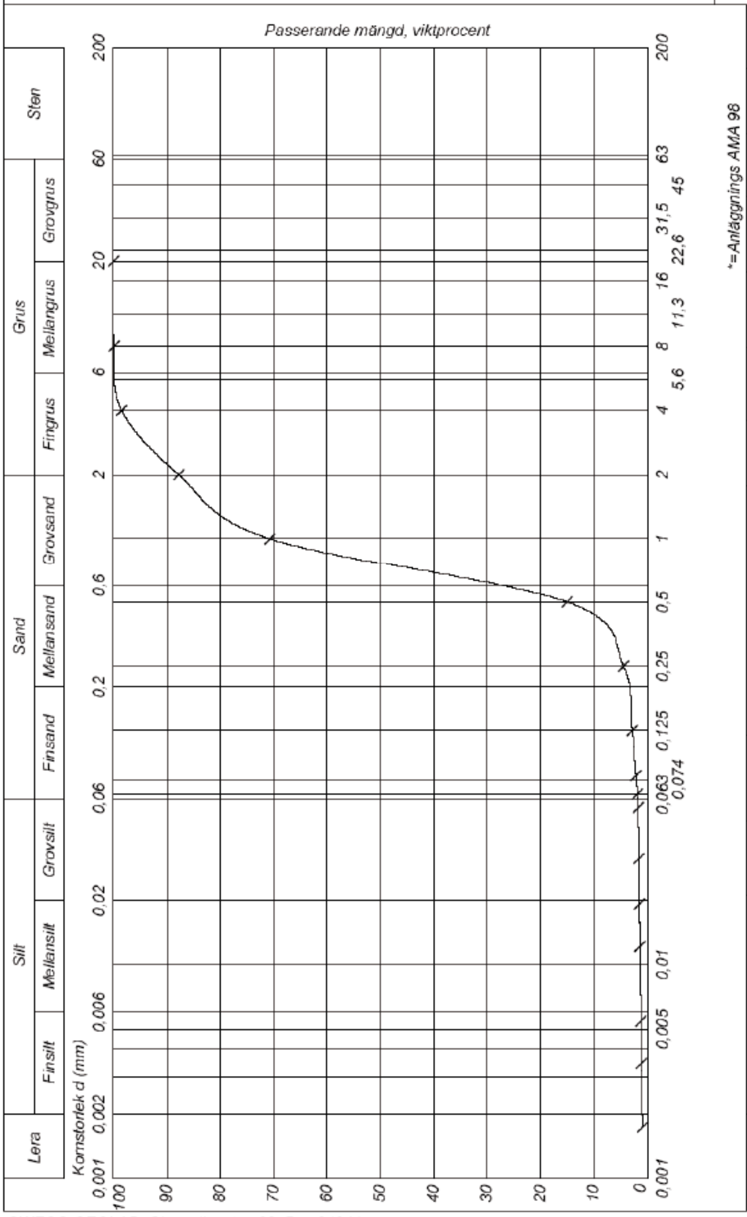
1(1)

PSM007180, 0.3 m, Sand

Kornfördelning
enl. SS027123 och SS027124

SWECO GEOLAB

Projekt: **Prov nr 28200-28219**		*Datum:*	2005-10-28
Uppdragsnr: 40092	*Provtagningsdatum:* 2005-08-26	*Löp-nr:*	14436
Uppdragsgivare: SGU, Uppsala		*Gransk./Sign:*	



*=Anläggnings AMA 98

d90	d60	d10	Tjäl-farlighet	Mtrl % > mm	Glödgn.-förlust %	Siktat Prov (g)	Benämning	Gäller mellan (m)	Djup (m)	Prov-beteckning	Sektion Borrhål
2,306	0,875	0,360	2/1*			426	Sand (SGU serie Ae)		0,3	—x—	PSM 007180 28213

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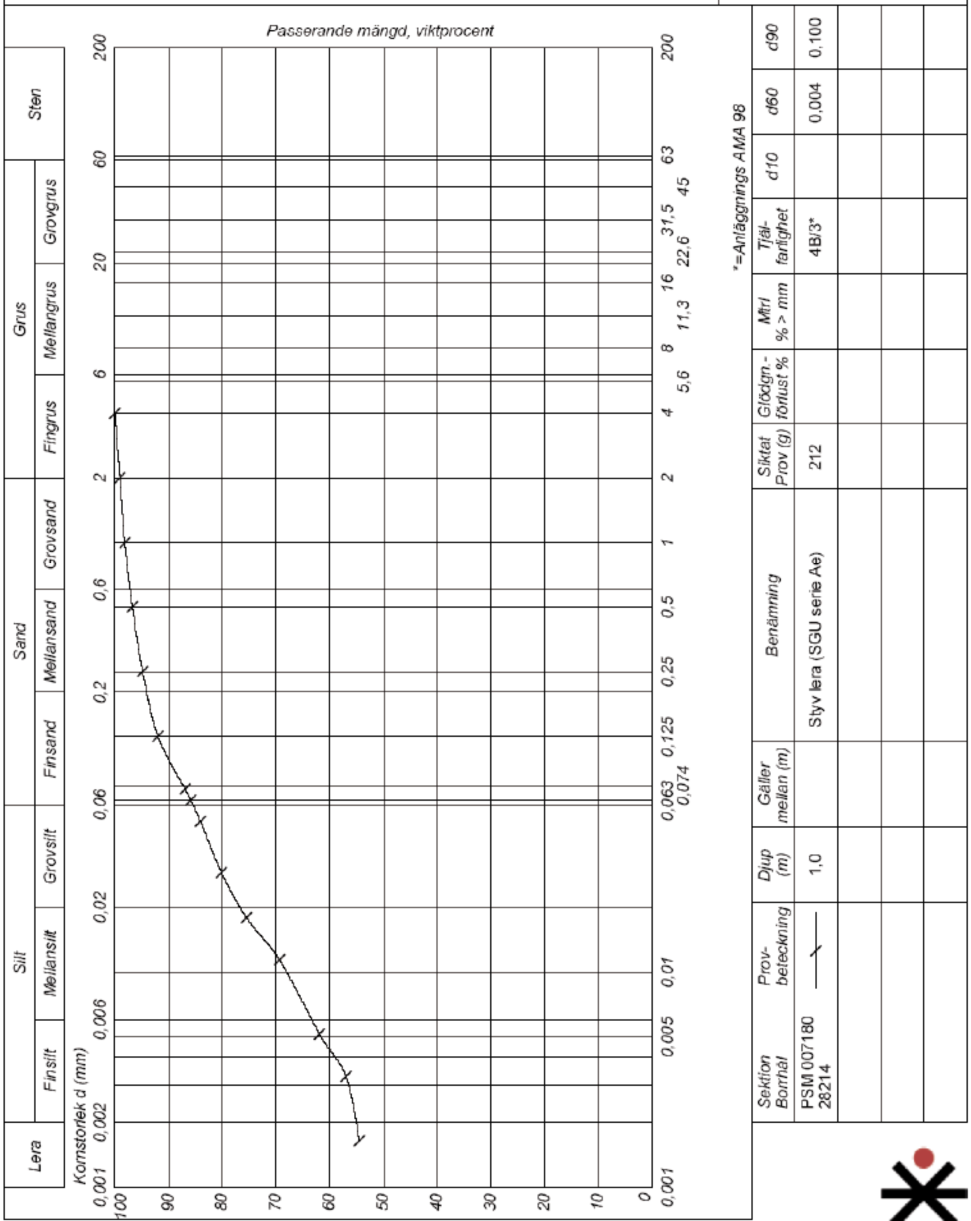
1(1)

PSM007180, 1.0 m, Heavy clay

Kornfördelning
enl. SS027123 och SS027124

SWECO GEOLAB

Projekt: **Prov nr 28200-28219**		*Datum:*	2005-10-28
Uppdragsnr: 40092	*Provtagningsdatum:* 2005-08-25	*Löp-nr:*	14436
Uppdragsgivare: SGU, Uppsala		*Gransk./Sign:*	



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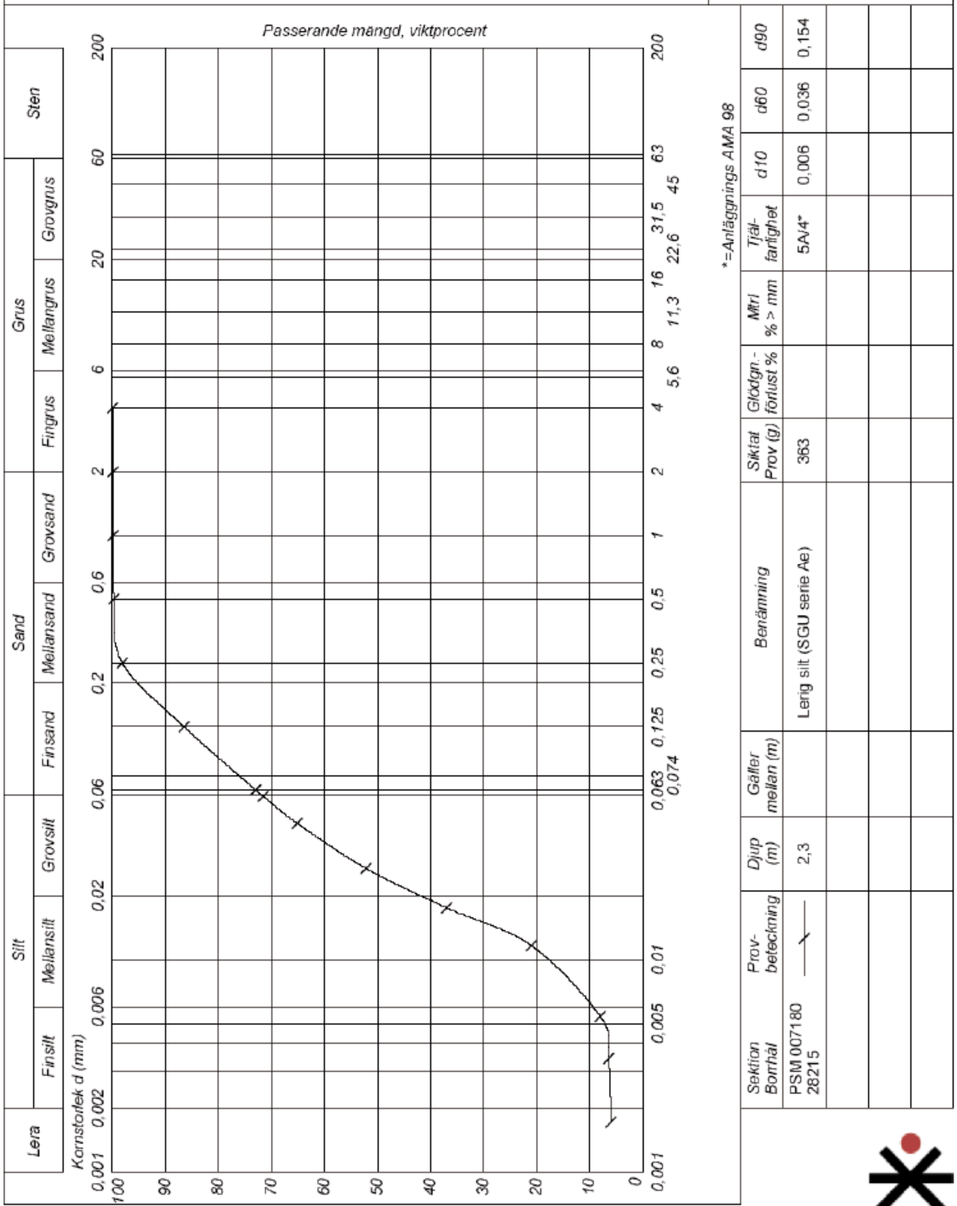
1(1)

PSM007180, 2.3 m, Clayey silt

Kornfördelning
enl. SS027123 och SS027124

SWECO GEOLAB

Projekt: **Prov nr 28200-28219**		*Datum:*	2005-10-28
Uppdragsnr: 40092	*Provtagningsdatum:*	*Löp-nr:*	14436
Uppdragsgivare: SGU, Uppsala		*Gransk./Sign:*	



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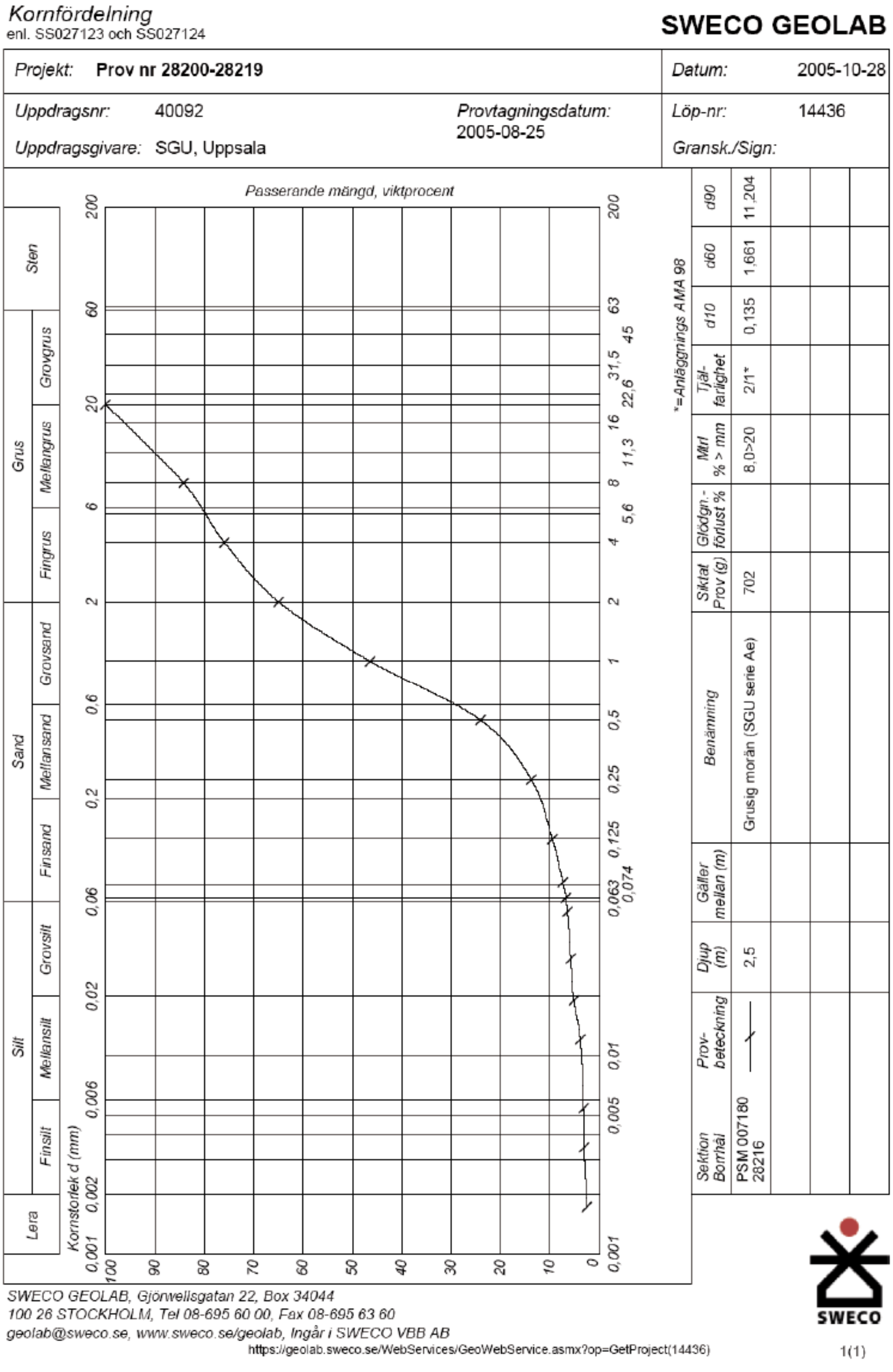
SWECO

1(1)

PSM007180, 2.5 m, Gravelly till

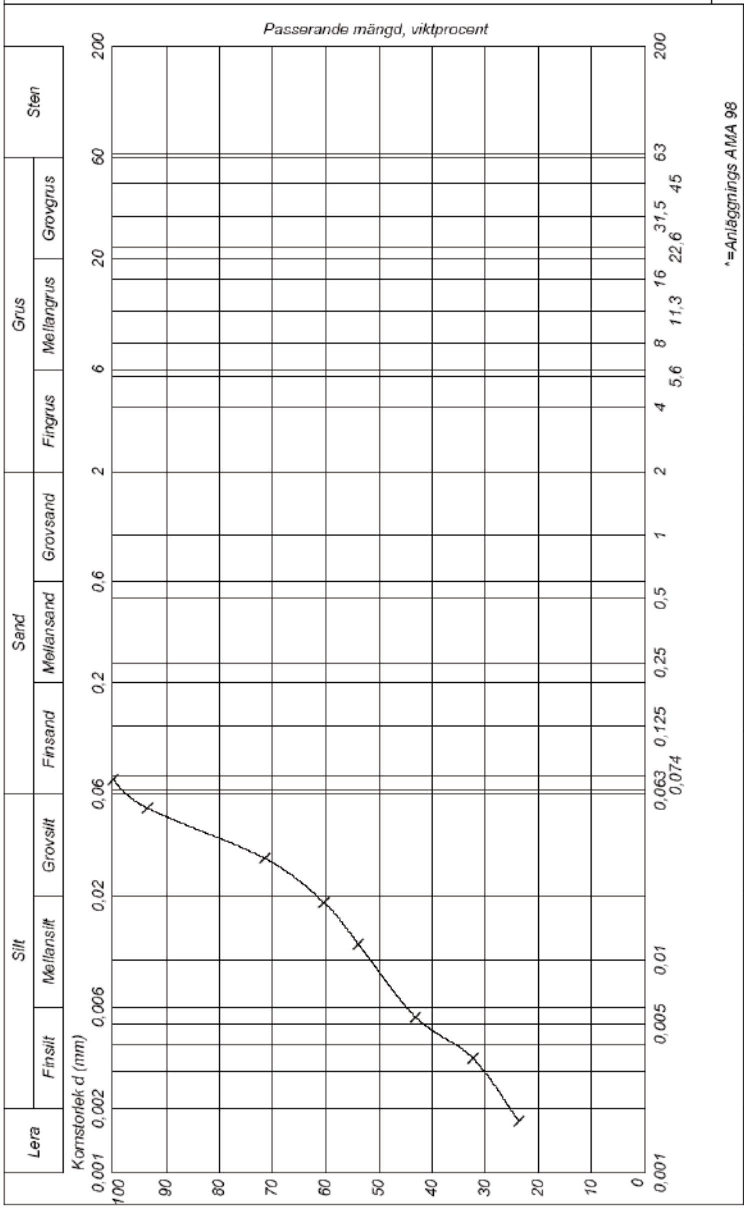


PSM007190, 1.1–1.3 m, Gyttja

Kornfördelning
enl. SS027123 och SS027124

SWECO GEOLAB

Projekt: **Prov nr 28200-28219**		*Datum:*	2005-10-28
Uppdragsnr: 40092	*Provtagningsdatum:* 2005-08-17	*Löp-nr:*	14436
Uppdragsgivare: SGU, Uppsala		*Gransk./Sign:*	



*=Anläggnings AMA 98

Sektion Borrhål	Prov-beteckning	Djup (m)	Gäller mellan (m)	Benämning	Siktat Prov (g)	Glödgn.-förlust %	Mtrl % > mm	Tjäl-farlighet	d10	d60	d90
PSM 007190 28217	—+—		1,1-1,3	Gyttja (SGU serie Ae)		31,7		6B/1*		0,018	0,047

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SWECO

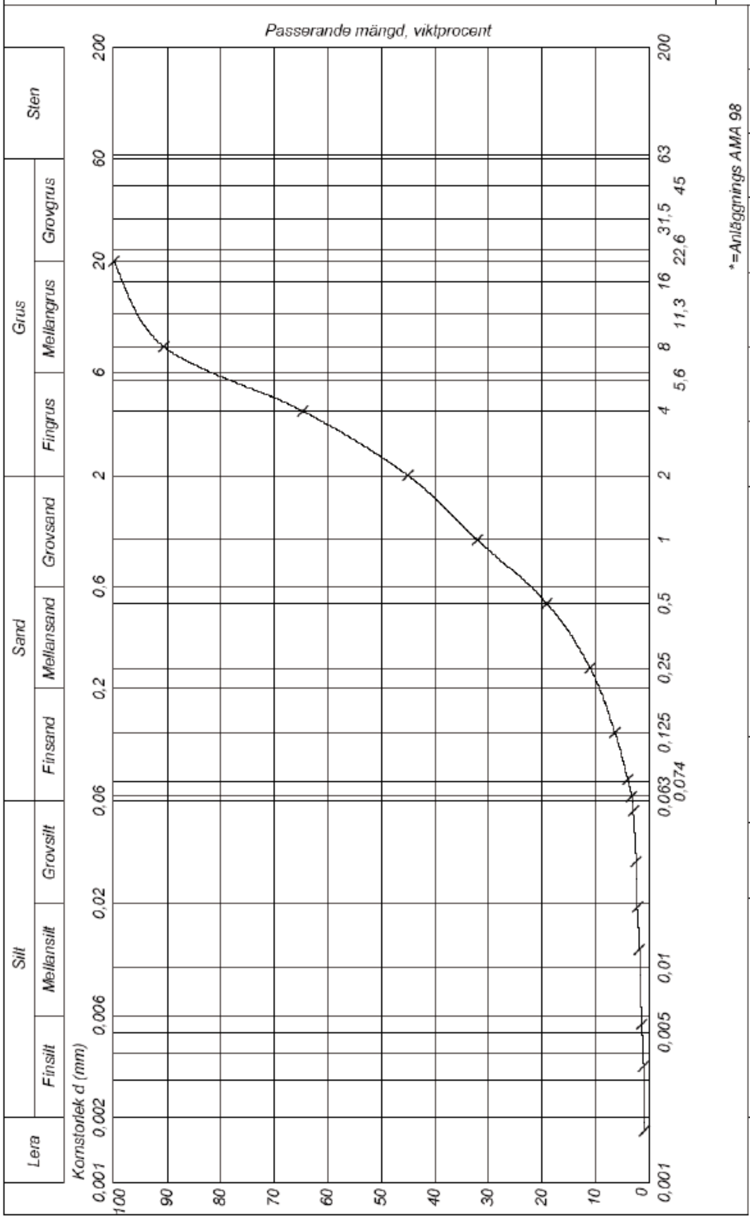
1(1)

SSM00224-13, 12.0–13.0 m, Sandy gravel

Kornfördelning
enl. SS027123 och SS027124

SWECO GEOLAB

Projekt: **Prov nr 28200-28219**	*Datum:* 2005-10-28
Uppdragsnr: 40092 *Provtagningsdatum:*	*Löp-nr:* 14436
Uppdragsgivare: SGU, Uppsala	*Gransk./Sign:*



*=Anläggnings AMA 98

d90	d60	d10	Tjäl-farlighet	Mtrl % > mm	Glödgn.-förlust %	Siktat Prov (g)	Benämning	Gäller mellan (m)	Djup (m)	Prov-beteckning	Sektion Borrhål
7,857	3,390	0,215	2/1*			708	Sandigt grus (SGU serie Ae)	12,0-13,0		SSM000224-13	28218

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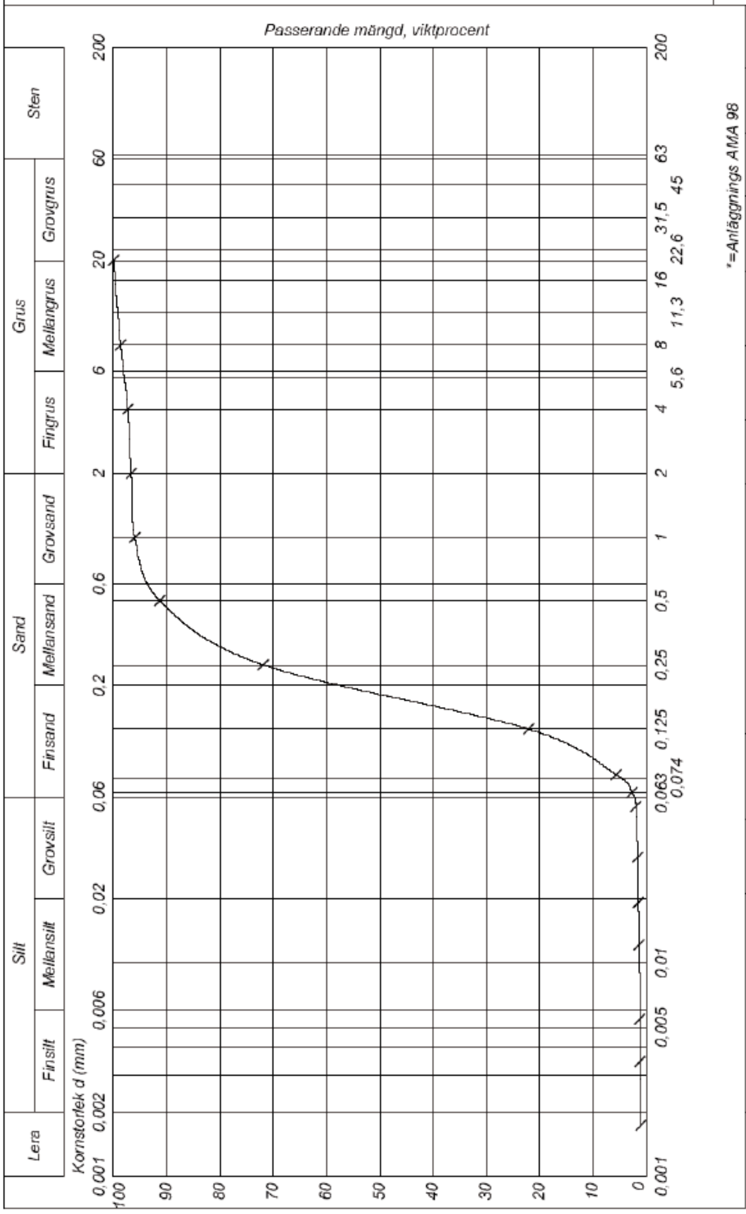
1(1)

SSM00225, 2.0–2.8 m, Sand

Kornfördelning
enl. SS027123 och SS027124

SWECO GEOLAB

Projekt:	**Prov nr 28200-28219**	*Datum:*	2005-10-28
Uppdragsnr: 40092	*Provtagningsdatum:*	*Löp-nr:*	14436
Uppdragsgivare: SGU, Uppsala		*Gransk./Sign:*	



Sektion Borrhål	Prov-beteckning	Djup (m)	Galler mellan (m)	Benämning	Siktat Prov (g)	Glödgn.-förlust %	Mtrl % > mm	Tjäl-farlighet	d10	d60	d90
SSM 000225-2 28219			2,0-2,8	Sand (SGU serie Ae)	299			2/1*	0,087	0,212	0,477

*=Anläggnings AMA 98

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1(1)

Porosity, water retention, water content, soil density and dry bulk density in profiles of the trenches 1, 3, 4 and 5

Site, level, cm	Volume, vol. %		Water retention, %					Water content %	Density g/cm³	Dry bulk density, g/cm³
	Material	Pore	Suction, cm							
			0	10	50	100	500			
PSM007160 A										
5–10	38.4	61.6	61.7	51.6	47.6	46.0	42.8	43.8	2.3	0.9
20–25	40.9	59.1	61.9	52.3	50.2	48.7	45.7	46.3	2.4	1.0
50–55	43.5	56.5	60.1	55.9	53.1	52.0	48.6	44.8	2.3	1.0
80–85	38.7	61.3	66.5	64.1	62.6	61.5	57.5	54.6	2.4	0.9
120–125	66.2	33.8	30.7	22.7	20.1	17.5	12.3	17.8	2.7	1.8
140–145	31.2	68.8	68.1	66.7	65.9	65.4	57.5	66.2	2.7	0.9
PSM007171 A										
5–10	23.6	76.4	72.6	63.0	59.4	57.8	52.8	57.8	2.1	0.5
20–25	23.4	76.6	82.2	73.7	70.1	68.4	59.8	68.6	2.1	0.5
50–55	56.9	43.1	39.1	17.9	13.0	11.5	8.8	15.3	2.6	1.5
80–85	61.5	38.5	33.4	18.0	11.6	9.8	7.0	19.6	2.7	1.6
120–125	58.1	41.9	43.7	42.5	42.2	41.3	37.6	43.0	2.7	1.6
170–175	40.2	59.8	63.9	62.3	61.9	61.4	55.1	61.5	2.7	1.1
250–255	42.0	58.0	62.0	59.0	58.4	57.5	52.7	58.3	2.8	1.2
PSM007171 B										
5–10	23.8	76.2	77.3	69.0	64.5	62.2	54.9	63.1	2.1	0.5
20–25	24.7	75.3	81.9	77.6	73.8	72.1	64.5	72.3	2.1	0.5
80–85	65.0	35.0	34.9	19.9	13.0	11.1	8.1	19.6	2.7	1.7
120–125	53.9	46.1	47.7	47.1	46.8	46.5	41.8	46.6	2.7	1.5
170–175	35.6	64.4	69.5	66.4	66.1	65.7	61.8	65.1	2.7	1.0
250–255	39.1	60.9	59.7	58.5	57.7	56.7	52.1	58.5	2.8	1.1
PSM007180 A										
5–10	47.0	53.0	56.8	44.7	29.1	25.3	19.9	17.5	2.5	1.2
20–25	46.6	53.4	54.8	45.7	29.6	25.3	18.8	17.2	2.5	1.2
50–55	62.2	37.8	33.0	27.4	7.9	6.3	4.4	4.3	2.6	1.6
80–85	63.0	37.0	39.4	39.1	38.3	37.5	33.5	29.1	2.7	1.7
120–125	66.7	33.3	41.7	33.1	30.4	29.6	26.0	22.8	2.7	1.8
170–175	60.5	39.5	47.0	45.6	45.1	44.9	42.3	40.5	2.7	1.7
250–255	63.0	37.0	41.8	39.5	39.2	38.7	34.8	38.4	2.6	1.7
PSM007190 A										
5–10	28.6	71.4	72.6	66.1	60.7	58.6	52.4	56.5	2.0	0.6
20–25	25.5	74.5	76.1	64.6	59.9	58.4	53.2	58.1	2.0	0.5
50–55	18.1	81.9	86.4	76.0	72.4	70.5	60.9	73.7	1.9	0.3
80–85	12.9	87.1	92.4	87.8	83.7	80.2	61.7	86.1	1.9	0.2
120–125	13.2	86.8	94.2	90.5	85.8	82.9	59.1	88.0	1.9	0.3
200	77.6	22.4	23.5	19.2	18.6	18.1	13.7	18.6	2.7	2.1
300	59.0	41.0	40.8	38.3	35.1	33.0	26.1	40.0	2.7	1.6

Appendix 7

Saturated hydraulic conductivity in profiles of the trenches 1, 3, 4 and 5 of the Oskarshamn area

Trench, level, cm	Conductivity, kx10^{-6}, m/s			
	After 1 hour	After 24 hours	After 1 hour	After 24 hours
Trench 1	PSM007160 A		PSM007160 B	
5–10	57.2	13.3	27.8	13.9
20–25	17.8	5.6	75.6	51.7
50–55	0.7	0.7	10.0	4.4
80–85	13.1	14.7	0.0	0.0
120–125	22.2	88.3	9.2	7.8
140–145	3.6	2.4	6.4	1.8
Trench 3	PSM007171 A		PSM007171 B	
5–10	4.2	2.1	12.5	3.1
20–25	7.2	2.8	5.3	15.8
50–55	2.3	1.5		
80–85	7.6	4.0	18.1	2.0
120–125	0.1	0.0	0.0	0.0
170–175	0.0	0.0	0.0	0.0
250–255			0.0	0.0
Trench 4	PSM007180 A		PSM007180 B	
5–10	26.9	6.1	153.1	27.5
20–25	11.9	3.1	165.3	48.9
50–55	27.2	4.2	82.2	17.2
80–85	0.0	0.0	0.0	0.4
120–125	0.0	0.0		
170–175	0.0	0.0	0.0	0.0
250–255	0.0	0.0		
Trench 5	PSM007190 A		PSM007190 B	
5–10	50.6	17.2	6.1	4.7
20–25	157.5	108.3	63.9	13.3
50–55			8.9	10.8
80–85			12.2	3.1
120–125			16.4	4.4
200	0.0	0.0	0.0	0.2
300			0.3	0.0

Appendix 8

Element		PSM007160 Gyttja clay 0.7–0.8 m	PSM007160 Sand/gravel 1.0–1.1m	PSM007160 Glacial clay 1.25–1.3 m	PSM007160 Gravelly till 2.2 m	PSM007162 Sandy till 1.0–1.2 m	PSM007163 Sandy till 1.3 m
TS	%	60	92	72.2	93	92.1	92
SiO_2	% TS	67.8	68.9	62.9	69.3	71.4	68.3
Al_2O_3	% TS	12.4	15.2	16.2	13.8	14.1	14.5
CaO	% TS	1.2	2.18	1.54	1.13	1.95	2.77
Fe_2O_3	% TS	6.43	3.37	6.61	3.22	3.3	4.83
K_2O	% TS	2.86	3.93	4.26	5	3.99	3.65
MgO	% TS	1.74	0.791	2.35	1.7	1.05	1.06
MnO	% TS	0.0488	0.0455	0.0645	0.0575	0.0496	0.0715
Na_2O	% TS	1.35	3.82	1.75	3.71	3.52	3.77
$P2O_5$	% TS	0.0611	0.12	0.187	0.157	0.173	0.163
TiO_2	% TS	0.483	0.298	0.694	0.432	0.476	0.444
Summa	% TS	94.4	98.7	96.6	98.5	100	99.6
LOI	% TS	6.4	1.2	4.6	1.4	1.3	0.9
As	mg/kg TS	6.88	2.22	3.13	1.17	1.05	0.722
Ba	mg/kg TS	473	1030	686	942	906	840
Cd	mg/kg TS	0.0825	0.039	0.166	0.0176	0.0354	0.0269
Ce	mg/kg TS	66.7	38.3	93.5	67.1	41.6	58.1
Cr	mg/kg TS	79.6	46.3	85.9	28.3	35.3	58.2
Cu	mg/kg TS	39.8	15.6	25.9	8.35	8.99	9.09
Dy	mg/kg TS	4.75	1.6	5.7	1.66	1.91	2.68
Er	mg/kg TS	2.59	1.33	3.17	1.21	0.996	1.45
Eu	mg/kg TS	0.852	0.38	1.31	0.611	0.474	0.774
Ga	mg/kg TS	4.57	11.3	17.3	12.2	10.7	14.9
Gd	mg/kg TS	4.02	2.94	5.4	2.38	1.71	2.27
Hf	mg/kg TS	2.37	2.7	6.3	4.15	5.35	4.39
Hg	mg/kg TS	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Ho	mg/kg TS	0.916	0.369	1.11	0.362	0.382	0.562
La	mg/kg TS	36.9	18.6	42.9	33.1	20.1	27.2
Lu	mg/kg TS	0.366	0.0985	0.593	0.212	0.197	0.236
Mo	mg/kg TS	0.347	1.05	0.418	0.895	0.797	1.08
Nb	mg/kg TS	11	6.22	14.9	8.93	9.92	9.91
Nd	mg/kg TS	39.2	16.1	47.6	29.1	20.1	29.3
Ni	mg/kg TS	27.6	12.6	32.8	12.1	8.08	12.5
Pr	mg/kg TS	9.39	4.34	10.7	7.57	4.72	6.49
Rb	mg/kg TS	107	96	155	105	93.8	98.5
S	mg/kg TS	150	78.1	73.5	58.7	34.7	49.8
Sc	mg/kg TS	11.9	4.56	13.9	5.15	5.72	5.68
Sm	mg/kg TS	5.68	2.55	7.61	4.81	2.91	4.41
Sn	mg/kg TS	0.562	0.717	0.677	1.35	0.965	0.866
Sr	mg/kg TS	115	581	179	354	497	554
Ta	mg/kg TS	0.89	0.536	1.36	0.885	0.874	0.829
Tb	mg/kg TS	0.968	0.311	1.05	0.365	0.371	0.427
Th	mg/kg TS	14.9	8.67	18.4	17.3	10.5	10.2
Tm	mg/kg TS	0.373	0.21	0.599	0.131	0.212	0.209
U	mg/kg TS	2.7	1.87	3.65	3.05	2.15	1.94
V	mg/kg TS	83.5	34.2	100	33.7	44.5	57.8
W	mg/kg TS	2.09	1.46	2.65	1.05	1.26	1.69
Y	mg/kg TS	35.9	15	37.8	14.1	15.3	20
Yb	mg/kg TS	2.48	1.46	3.36	1.24	1.38	1.93
Zr	mg/kg TS	111	136	248	173	254	198

Element		PSM007170 Silt 1.2 m	PSM007171 Gyttja clay 0.5 m	PSM007171 Sand/gravel 1.25 m	PSM007171 Glacial clay 1.4 m	PSM007171 Glacial clay 1.8 m	PSM007171 Gravelly till 3.2 m	PSM007173 Sandy till 1.5 m
TS	%	73.9	44.5	88.7	73.6	70.3	93.6	95.2
SiO_2	% TS	66.5	77.8	66.9	66.1	63.8	71.6	65.2
Al_2O_3	% TS	14	5.62	14.7	15.2	15.6	12.9	14.6
CaO	% TS	1.36	0.304	2.19	1.33	1.63	2.06	2.5
Fe_2O_3	% TS	7.42	2.04	5.19	5.42	7.05	3.67	5
K_2O	% TS	3.84	1.32	3.74	4.09	4.13	3.65	4.42
MgO	% TS	1.73	0.521	1.77	1.77	2.39	1.3	2.31
MnO	% TS	0.0806	0.0234	0.0678	0.0523	0.0864	0.0588	0.0693
Na_2O	% TS	2.19	0.597	3.44	2.28	2.06	3.31	3.27
P_2O_5	% TS	0.151	0.101	0.217	0.17	0.181	0.168	0.287
TiO_2	% TS	0.643	0.295	0.528	0.639	0.689	0.484	0.707
Summa	% TS	97.9	88.6	98.7	97.1	97.6	99.2	98.4
LOI	% TS	3	10.5	2	3.4	3.4	1.7	1.7
As	mg/kg TS	2.74	1.55	3.21	3.58	3.22	0.795	0.71
Ba	mg/kg TS	678	218	994	686	705	951	1010
Cd	mg/kg TS	0.281	0.106	0.039	0.147	0.0722	0.0379	0.0232
Ce	mg/kg TS	54.6	21.6	40.5	71.5	72.6	78.8	54.7
Cr	mg/kg TS	102	54	45.5	72.9	89.9	32.9	41.4
Cu	mg/kg TS	30.8	43.3	11.6	21.2	29.4	14.1	18.1
Dy	mg/kg TS	2.85	1.18	2	3.62	4.06	3.09	2.09
Er	mg/kg TS	1.76	0.552	1.02	1.83	2.42	1.5	1.22
Eu	mg/kg TS	0.543	0.218	0.558	0.697	0.748	0.953	0.683
Ga	mg/kg TS	10.1	< 1	10.6	13.7	14	11.8	10.9
Gd	mg/kg TS	2.94	1.22	2.13	3.91	3.57	2.86	2.06
Hf	mg/kg TS	5.24	1.41	3.34	4.96	4.34	5.42	3.58
Hg	mg/kg TS	< 0.04	0.0432	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Ho	mg/kg TS	0.588	0.195	0.371	0.771	0.834	0.657	0.463
La	mg/kg TS	24.5	11.3	18.5	32.2	31.7	39	26.6
Lu	mg/kg TS	0.257	0.108	0.198	0.298	0.27	0.311	0.189
Mo	mg/kg TS	1.71	2.13	1.96	0.434	0.648	0.806	0.756
Nb	mg/kg TS	12.3	4.16	8.46	13.5	14.8	10.7	7.05
Nd	mg/kg TS	24.2	11.8	21.3	29.2	31.9	38.8	27.7
Ni	mg/kg TS	30.1	10.4	15.3	21.8	27.6	9.93	15.7
Pr	mg/kg TS	6.05	2.11	4.9	8.03	7.73	9.6	5.96
Rb	mg/kg TS	117	37.6	103	133	123	129	123
S	mg/kg TS	3240	806	171	2060	199	297	409
Sc	mg/kg TS	10.9	5.04	7.88	11.4	12.9	5.25	8.73
Sm	mg/kg TS	4.55	1.26	2.79	5	4.83	4.36	4.14
Sn	mg/kg TS	1.22	0.247	0.81	0.822	1.24	1.07	0.951
Sr	mg/kg TS	213	54.7	499	221	200	358	504
Ta	mg/kg TS	1.06	0.335	0.672	1.13	3.62	0.994	0.633
Tb	mg/kg TS	0.446	0.185	0.402	0.679	0.776	0.709	0.488
Th	mg/kg TS	18.4	10	7.55	17.3	19.1	13	8.53
Tm	mg/kg TS	0.295	< 0.1	0.135	0.263	0.308	0.301	0.198
U	mg/kg TS	3.68	6.26	1.74	3.23	3.2	5.03	2.21
V	mg/kg TS	85.4	32.5	70.3	82.3	91.6	47.7	73.9
W	mg/kg TS	2.06	0.895	1.09	2.61	1.52	3.28	2.4
Y	mg/kg TS	25.3	10.2	17	29.3	35.4	21	18.1
Yb	mg/kg TS	2.6	0.627	1.44	2.65	2.94	1.43	1.68
Zr	mg/kg TS	290	93	201	255	237	214	152

Element		PSM007180 Sand 0.3 m	PSM007180 Glacial clay 1.4 m	PSM007180 Silt layer (till) 2.3 m	PSM007180 Sandy till 2.5 m	PSM007190 Gyttja 1.1–1.3 m	SSM00224 Sand/gravel 12–13 m	SSM00225 Sand 2–2.8 m
TS	%	95.3	80.6	84.7	92.9	24.8	94.7	87.6
SiO_2	% TS	72.4	61.5	70.5	69.4	38	66.6	73.9
Al_2O_3	% TS	14.3	15.5	12.6	14.6	3.29	15.4	12.7
CaO	% TS	1.49	1.48	2.08	1.71	1.77	2.37	1.62
Fe_2O_3	% TS	2.82	8.19	5.44	3.87	1.92	4.43	3.48
K_2O	% TS	4.38	4.25	4.01	4.43	0.818	4.17	4.08
MgO	% TS	0.493	2.27	1.04	1.02	0.576	1.62	0.544
MnO	% TS	0.0424	0.0873	0.0748	0.0567	0.0224	0.0908	0.0482
Na_2O	% TS	3.8	1.84	2.86	3.74	0.382	3.85	3.35
P_2O_5	% TS	0.0903	0.187	0.233	0.137	0.19	0.17	0.107
TiO_2	% TS	0.203	0.694	0.644	0.365	0.13	0.491	0.459
Summa	% TS	100	96	99.5	99.3	47.1	99.2	100.3
LOI	% TS	0.5	3.8	0.8	0.8	38.4	1.3	0.7
As	mg/kg TS	1.2	5.22	1.17	0.932	6.45	0.821	1.05
Ba	mg/kg TS	945	693	772	1100	131	1040	812
Cd	mg/kg TS	0.0381	0.079	0.073	0.0213	0.877	0.0695	0.0588
Ce	mg/kg TS	24.7	85.3	82.4	50.6	56.3	55.4	71.6
Cr	mg/kg TS	33.3	86.2	85.3	48.8	28	56.9	29.5
Cu	mg/kg TS	7.15	27.4	10.3	10.5	55.2	16.5	20.1
Dy	mg/kg TS	1.04	4.86	4.51	1.64	3.09	2.27	3.19
Er	mg/kg TS	0.568	2.89	2.19	1.01	2.06	0.905	1.46
Eu	mg/kg TS	0.209	0.836	1.01	0.42	0.77	0.389	0.703
Ga	mg/kg TS	11	17.4	12.2	13.5	< 1	15	9.84
Gd	mg/kg TS	1.41	4.87	3.47	1.42	3.16	2.37	3.33
Hf	mg/kg TS	2.2	6.43	10.4	3.34	0.821	3.74	5.63
Hg	mg/kg TS	< 0.04	< 0.04	< 0.04	< 0.04	0.0818	< 0.04	< 0.04
Ho	mg/kg TS	0.266	0.84	0.863	0.368	0.638	0.441	0.692
La	mg/kg TS	13.5	37.7	38.4	25.7	28.5	25.3	32.1
Lu	mg/kg TS	0.142	0.48	0.486	0.17	0.34	0.185	0.372
Mo	mg/kg TS	1.68	0.637	1.36	0.982	8.65	1.04	1.58
Nb	mg/kg TS	4.76	15.6	16.9	7.79	0.417	8.31	13.6
Nd	mg/kg TS	11.3	40.9	41.9	21	32.3	26.2	31.2
Ni	mg/kg TS	9.5	28.5	12.7	9.27	26.1	15.5	8.26
Pr	mg/kg TS	2.39	10.3	9.69	5.37	7.05	6.33	8.56
Rb	mg/kg TS	140	142	117	114	26.7	125	114
S	mg/kg TS	90.4	125	334	92.4	19700	188	77.1
Sc	mg/kg TS	2.95	13.1	7.14	4.56	4.04	6.28	4.08
Sm	mg/kg TS	1.47	6.5	6.09	2.73	4.3	3.86	4.58
Sn	mg/kg TS	0.537	1.21	1.36	0.831	0.428	0.936	1.39
Sr	mg/kg TS	418	173	290	515	90.1	576	315
Ta	mg/kg TS	0.502	1.47	1.12	0.616	0.183	0.675	0.958
Tb	mg/kg TS	0.222	0.873	0.777	0.397	0.642	0.441	0.657
Th	mg/kg TS	4.98	19.4	18	9.27	6.6	10.6	11.8
Tm	mg/kg TS	0.173	0.442	0.426	0.144	0.308	0.181	0.348
U	mg/kg TS	1.07	3.09	4.1	2.12	6.82	3.01	2.57
V	mg/kg TS	20.7	94.7	59	38.9	19.4	51.3	37.2
W	mg/kg TS	0.874	1.76	2.43	1.14	1.59	1.7	1.97
Y	mg/kg TS	8.53	37.7	34.9	14.5	24.7	16.5	24.9
Yb	mg/kg TS	0.831	3.32	3.26	1.17	1.99	1.01	2.2
Zr	mg/kg TS	88.5	276	474	163	33.5	181	242

Element		PSM007160 Gyttja clay 0.7–0.8 m	PSM007160 Sand/gravel 1.0–1.1m	PSM007160 Glacial clay 1.25–1.3 m	PSM007160 Gravelly till 2.2 m	PSM007162 Sandy till 1.0–1.2 m	PSM007163 Sandy till 1.3 m
TS	%	60	92	72.2	93	92.1	92
Ag	mg/kg TS	0.0783	0.0474	0.0799	< 0.04	< 0.04	< 0.04
B	mg/kg TS	< 1	< 1	1.16	< 1	< 1	< 1
Be	mg/kg TS	2.08	0.892	2.37	1.08	0.659	0.7
Co	mg/kg TS	11.7	4.71	13.7	6.5	4.86	5.93
Cs	mg/kg TS	5.79	1.74	6.1	0.558	1.42	1.51
Pb	mg/kg TS	15.2	6.62	22	6.71	7.96	8.34
Sb	mg/kg TS	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Se	mg/kg TS	< 1	< 1	< 1	< 1	< 1	< 1
Tl	mg/kg TS	0.559	0.178	0.639	0.0619	0.146	0.169
Li	mg/kg TS	28.7	15.5	43.1	27.3	17.9	16.1
Zn	mg/kg TS	94.9	40.4	103	67.1	45.8	44.1
Br	mg/kg TS	1.79	1.14	1.44	1.54	1.08	0.646
Cl	mg/kg TS	< 25	63.3	32.1	77.8	52.1	51.1
I	mg/kg TS	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Element		PSM007170 Silt 1.2 m	PSM007171 Gyttja clay 0.5 m	PSM007171 Sand/gravel 1.25 m	PSM007171 Glacial clay 1.4 m	PSM007171 Glacial clay 1.8 m	PSM007171 Gravelly till 3.2 m	PSM007173 Sandy till 1.5 m
TS	%	73.9	44.5	88.7	73.6	70.3	93.5	95.2
Ag	mg/kg TS	0.0843	0.0538	0.0407	0.0691	0.106	0.045	0.0514
B	mg/kg TS	< 1	< 1	< 1	< 1	< 1	< 1	1.91
Be	mg/kg TS	1.63	1.01	1.15	1.89	2.57	2.78	3.12
Co	mg/kg TS	14.1	3.21	7.56	12.7	15.7	6.47	11.8
Cs	mg/kg TS	4.88	3.38	2.22	5.09	6.69	2.69	3.46
Pb	mg/kg TS	17.9	8.55	5.81	16	19.1	6.83	7.29
Sb	mg/kg TS	< 0.04	0.0418	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Se	mg/kg TS	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Tl	mg/kg TS	0.578	0.308	0.321	0.538	0.713	0.273	0.286
Li	mg/kg TS	30.6	11.8	26.6	32.3	40.3	25.1	35.2
Zn	mg/kg TS	100	23.9	67.1	83.9	94	58.6	76.4
Br	mg/kg TS	1.03	9.67	1.54	0.768	< 0.5	0.642	0.649
Cl	mg/kg TS	28.3	56.9	42.7	32.6	< 25	65.4	53.7
I	mg/kg TS	< 0.5	2.83	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Element		PSM007180 Sand 0.3 m	PSM007180 Glacial clay 1.4 m	PSM007180 Silt layer (till) 2.3 m	PSM007180 Sandy till 2.5 m	PSM007190 Gyttja 1.1–1.3 m	SSM00224 Sand/gravel 12–13 m	SSM00225 Sand 2–2.8 m
TS	%	95.3	80.6	84.7	92.9	24.8	94.7	87.6
Ag	mg/kg TS	< 0.04	0.0932	0.0531	< 0.04	0.203	0.0558	0.0533
B	mg/kg TS	< 1	1.73	1.8	< 1	1.12	< 1	1.14
Be	mg/kg TS	0.72	2.41	1.41	1.01	1.38	1.9	0.732
Co	mg/kg TS	4.8	17.4	7.19	6.07	2.98	9.29	3.47
Cs	mg/kg TS	1.01	6.8	2.58	2.22	1.5	1.57	0.826
Pb	mg/kg TS	5.67	20.4	13	8.35	6.83	8.54	8.03
Sb	mg/kg TS	< 0.04	< 0.04	0.0422	< 0.04	0.0454	< 0.04	0.0491
Se	mg/kg TS	< 1	< 1	< 1	< 1	1.2	< 1	< 1
Tl	mg/kg TS	0.155	0.669	0.226	0.149	0.195	0.198	0.164
Li	mg/kg TS	16.3	43.1	24.4	20.5	9.18	28.7	12.3
Zn	mg/kg TS	27	96.9	47.8	44.3	47.6	90	29.6
Br	mg/kg TS	1	0.802	< 0.5	0.914	32.3	< 0.5	0.686
Cl	mg/kg TS	59.2	< 25	29.2	62.8	27	53.1	60.3
I	mg/kg TS	< 0.5	< 0.5	< 0.5	< 0.5	4.56	< 0.5	< 0.5

Appendix 9

Appendix 9a
Oskarshamn area trenches. Carbon and nitrogen concentrations and pH_{H_2O} and pH_{CaCl_2} in the profiles of trench 1 and 3

Trench	Site	Type	Depth, cm	C_{tot}, %	N_{tot}, %	pH_{H_2O}	pH_{CaCl_2}
Trench 1	PSM007160	Humus B	0–18	4.04	0.401	5.54	4.84
		Humus A	0–18	3.74	0.39	5.85	5.11
			–10	3.46	0.37	5.88	5.24
			–20	2.18	0.26	6.09	5.27
			–65	0.43	0.11	6.55	5.64
			–100	0.59	0.14	6.49	5.78
			–150	0.03	0.02	6.50	5.79
			–200	0.03	0.01	6.21	5.67
			–250	0.06	0.02	6.02	5.79
			–300	0.09	0.03	6.59	6.29
	PSM007162		–10	2.55	0.28	5.98	5.01
			–20	1.79	0.22	5.77	4.95
			–65	0.65	0.13	5.80	4.74
			–100	0.11	0.03	5.91	4.87
			–150	0.06	0.01	6.13	5.05
			–200	0.09	0.02	6.22	5.25
	PSM007162		–10	2.49	0.26	5.52	4.25
			–20	2.13	0.24	5.09	3.99
			–65	0.46	0.10	5.71	4.36
			–100	0.19	0.05	5.84	4.86
			–150	0.07	0.02	6.08	5.16
Trench 3	PSM007170	Humus A	0–18	44.20	1.89	4.46	3.54
		Humus B	0–18	40.90	1.71	4.46	3.56
	PSM007171		–10	4.85	0.50	4.72	4.00
			–20	3.28	0.38	4.73	3.99
		B5	–49	0.78	0.07	5.23	4.46
			–65	0.61	0.05	5.33	4.22
			–100	0.21	0.05	5.19	4.88
			–150	0.21	0.05	6.55	5.90
			–200	0.33	0.05	7.06	6.40
			–250	0.38	0.06	7.80	6.65
			–300	0.14	0.01	7.84	6.74
			–350	0.22	0.02	8.06	6.78
	PSM007173		–10	1.01	0.18	4.77	3.94
			–20	1.01	0.14	5.06	4.02
		B5	–49	0.63	0.07	5.22	3.99
			–65	0.15	0.02	5.51	4.26
			–100	0.20	0.05	5.53	5.18
			–150	0.25	0.05	6.85	6.20
			–200	0.26	0.05	6.90	6.15

Trench	Site	Type	Depth, cm	C_{tot}, %	N_{tot}, %	pH_{H_2O}	pH_{CaCl_2}
			–250	0.16	0.02	7.15	6.46
			–300	0.09	0.02	7.67	6.56
			–350	0.13	0.03	6.40	5.55
	PSM007174		–10	1.05	0.19	4.88	3.87
			–20	1.23	0.17	4.95	4.04
		B5	–60	0.20	0.03	5.56	4.39
			–65	0.36	0.04	5.43	4.28
			–100	0.47	0.08	5.96	5.20
			–150	0.38	0.05	6.23	5.53
			–200	0.21	0.05	6.64	5.95

Appendix 9b
Oskarshamn area trenches. Carbon and nitrogen concentrations and pH_{H_2O} and pH_{CaCl_2} in the profiles of trench 4 and 5

Trench	Site	Type	Depth, cm	C_{tot}, %	N_{tot}, %	pH_{H_2O}	pH_{CaCl_2}
Trench 4	PSM007180	Humus A	0–18	3.75	0.29	5.79	5.36
		Humus B	0–18	4.45	0.34	5.77	4.81
			–10	2.77	0.23	5.59	5.04
			–20	2.57	0.21	5.78	4.96
		B5	–52	0.12	0.02	6.17	5.04
			–65	0.18	0.02	6.06	5.32
			–100	0.42	0.04	6.17	5.09
			–150	0.26	0.04	6.46	5.57
			–200	0.24	0.05	6.73	6.19
			–250	0.05	0.01	6.90	6.42
			–300	0.16	0.01	6.65	6.09
	PSM007181		–10	0.67	0.07	5.30	4.29
			–20	0.60	0.07	5.23	4.31
		B5	–55	0.73	0.08	5.98	4.67
			–65	0.33	0.05	5.67	4.74
			–100	0.19	0.03	6.05	5.55
			–150	0.07	0.02	6.30	5.67
			–200	0.04	0.00	6.56	5.50
			–250	0.05	0.02	6.48	5.61
	PSM007183		–10	0.07	0.04	5.97	4.46
			–20	0.17	0.02	6.01	4.55
		B5	–53	0.19	0.03	5.88	4.62
			–65	0.46	0.05	5.14	4.12
Trench 5	PSM007190	Humus A	0–18	22.43	1.46	6.48	5.67
		Humus B	0–18	23.58	1.59	6.06	5.23
			–10	17.75	1.28	5.50	5.04
			–20	17.59	1.29	5.68	5.21
			–65	18.89	1.73	5.26	4.65
			–100	18.44	1.83	5.24	4.96
			–105	17.84	1.46	6.81	6.57
			–150	18.17	1.84	6.32	6.16
			–200	0.15	0.02	7.13	6.51
			–300	0.73	0.08	7.11	6.71

Appendix 10a
Soil chemistry in profiles PSM007160, PSM007171, PSM007180 and PSM007190. P_{AL}, P_{HCL}, Mn, Na, Ca and Mg extracted in 1 M_{NH_4Ac}, at pH 7, ditionit citrate and *Aqua Regia*

Profile	Depth, cm	Chemical element, g/kg										
		P_{AL}	P_{HCl}	Mn_{NH_4Ac}	$Mn_{Aqua\ Regia}$	$Mn_{Dit.citr.}$	Mg_{NH_4Ac}	$Mg_{Aqua\ Regia}$	Ca_{NH_4Ac}	$Ca_{Aqua\ Regia}$	Na_{NH_4Ac}	$Na_{Aqua\ Regia}$
PSM007160	–10	0.11	0.56	0.015	0.29	0.330	0.27	2.48	2.29	2.43	0.021	0.28
	–20	0.06	0.38	0.004	0.23	0.210	0.33	2.93	2.56	2.51	0.021	0.07
	–65	0.02	0.14	0.001	0.13	0.054	1.24	4.69	3.47	3.27	0.064	0.21
	–100	0.02	0.19	0.001	0.12	0.029	1.12	4.98	3.02	3.11	0.063	0.20
	–150	0.07	0.60	0.001	0.12	0.006	0.04	2.45	0.15	2.89	0.004	0.04
	–200	0.06	0.66	0.001	0.13	0.004	0.04	2.98	0.19	3.10	0.004	0.06
	–250	0.06	0.58	0.002	0.18	0.006	0.04	4.88	0.34	3.16	0.005	0.04
	–300	0.07	0.80	0.004	0.23	0.032	0.04	5.87	0.75	3.91	0.006	0.05
PSM007171	–10	0.04	0.26	< 0.001	0.02	0.001	0.01	0.80	0.06	0.17	0.021	0.09
	–20	0.03	0.26	< 0.001	0.02	0.002	0.02	0.88	0.07	0.22	0.018	0.04
	–65	0.01	0.51	0.001	0.14	0.002	0.02	4.56	0.06	1.77	0.006	0.04
	–100	0.14	0.67	0.013	0.26	0.026	0.36	6.45	0.90	2.68	0.041	0.15
	–150	0.19	0.65	0.014	0.31	0.064	0.45	8.03	1.46	3.61	0.078	0.23
	–200	0.13	0.62	0.016	0.33	0.121	0.40	7.67	3.00	6.52	0.075	0.24
	–250	0.11	0.63	0.011	0.30	0.092	0.44	7.75	3.05	7.25	0.077	0.23
	–300	0.04	0.68	0.010	0.22	0.040	0.04	5.42	1.35	5.32	0.006	0.05
	–350	0.04	0.83	0.011	0.28	0.071	0.07	6.24	1.90	8.21	0.012	0.11
PSM007180	–10	0.03	0.51	0.001	0.07	0.071	0.02	1.00	0.70	1.45	0.005	0.03
	–20	0.02	0.40	0.001	0.07	0.047	0.02	0.94	0.74	1.44	0.005	0.03
	–65	0.03	0.90	0.001	0.18	0.026	0.13	4.60	0.81	2.85	0.012	0.04
	–100	0.01	0.90	0.001	0.17	0.031	0.40	5.24	1.36	3.04	0.031	0.13

Profile	Depth, cm	Chemical element, g/kg										
		P_{AL}	P_{HCl}	Mn_{NH_4Ac}	$Mn_{Aqua\ Regia}$	$Mn_{Dit.citr.}$	Mg_{NH_4Ac}	$Mg_{Aqua\ Regia}$	Ca_{NH_4Ac}	$Ca_{Aqua\ Regia}$	Na_{NH_4Ac}	$Na_{Aqua\ Regia}$
	–150	0.02	0.51	0.001	0.23	0.041	0.45	6.55	1.23	3.53	0.037	0.17
	–200	0.14	0.66	0.001	0.28	0.076	0.44	7.40	1.72	4.03	0.048	0.22
	–250	0.18	0.68	0.006	0.18	0.022	0.02	3.46	0.64	4.60	0.005	0.10
	–300	0.07	1.02	0.011	0.19	0.052	0.02	3.75	1.27	4.53	0.006	0.04
PSM007190	–10	0.07	1.15	0.005	0.09	0.068	0.24	1.97	5.38	5.65	0.041	0.12
	–20	0.07	1.03	0.008	0.09	0.061	0.23	1.95	5.75	5.61	0.031	0.10
	–65	0.03	0.55	0.007	0.05	0.014	0.33	1.65	4.84	4.12	0.054	0.16
	–100	0.08	0.11	0.025	0.08	0.057	0.62	1.88	6.74	5.87	0.091	0.17
	–105	0.06	0.42	0.016	0.07	0.042	0.33	1.57	19.20	62.80	0.130	0.42
	–150	0.13	0.49	0.043	0.11	0.077	0.64	2.00	7.96	7.16	0.100	0.18
	–200	0.05	0.57	0.009	0.16	0.031	0.03	3.00	1.54	5.19	0.008	0.07
	–300	0.07	0.58	0.006	0.18	0.028	0.07	3.54	1.65	4.44	0.013	0.09

Appendix 10b
Soil chemistry in profiles PSM007160, PSM007171, PSM007180 and PSM007190. K_{AL}, K_{HCL}, K_{NH_4Ac}, $K_{Aqua\ Regia}$; Fe and Al extracted in *Aqua Regia* and ditionite citrate, and acidity and CEC

Profile	Depth, cm	Chemical element, g/kg								mmolc/100g	
		K_{NH_4Ac}	$K_{Aqua\ Regia}$	K_{AL}	K_{HCl}	$Fe_{Aqua\ Regia}$	$Fe_{Dit.citr.}$	$Al_{Aqua\ Regia}$	$Al_{Dit.citr.}$	Ac_{tot}	CEC_{tot}
PSM007160	–10	0.10	1.38	0.12	1.77	11.1	5.30	7.57	0.96	5.66	19.7
	–20	0.10	1.55	0.12	1.88	14.2	5.29	10.1	0.76	5.13	21.0
	–65	0.18	1.97	0.20	2.46	23.3	7.09	13.4	0.52	3.10	31.4
	–100	0.20	2.21	0.19	2.99	21.1	5.97	13.4	0.53	3.10	28.3
	–150	0.02	0.57	0.03	0.63	10.2	1.15	2.86	0.06	0.42	1.52
	–200	0.02	0.65	0.03	0.71	10.4	1.20	3.36	0.06	0.43	1.76
	–250	0.03	0.79	0.05	0.70	10.4	0.98	5.12	0.07	0.50	2.60
	–300	0.04	0.88	0.08	1.09	11.5	1.37	5.90	0.10	0.00	4.25
PSM007171	–10	0.04	0.50	0.07	0.86	2.28	1.04	5.46	3.81	19.0	19.7
	–20	0.04	0.53	0.05	1.02	2.23	0.68	4.15	2.08	14.3	14.9
	–65	0.04	1.13	0.05	1.19	9.59	2.06	6.19	0.67	3.50	4.06
	–100	0.22	3.31	0.23	4.46	22.8	1.89	12.5	0.32	2.12	10.4
	–150	0.33	4.16	0.35	5.31	24.0	3.81	15.4	0.51	0.31	12.6
	–200	0.31	3.85	0.33	4.90	22.7	7.03	13.8	0.85	< 0.001	19.4
	–250	0.37	3.95	0.40	5.65	22.9	4.93	14.0	0.69	< 0.001	20.2
	–300	0.04	1.14	0.05	1.35	15.0	0.98	5.49	0.06	< 0.001	7.29
	–350	0.06	1.34	0.07	1.42	17.1	1.10	7.01	0.08	< 0.001	10.3
PSM007180	–10	0.03	0.26	0.05	0.32	3.54	3.00	3.79	1.63	4.80	8.57
	–20	0.03	0.25	0.04	0.27	3.19	1.99	3.39	1.16	3.91	7.86
	–65	0.02	0.56	0.03	0.84	11.9	3.93	6.02	0.23	1.77	6.97
	–100	0.12	2.39	0.03	0.74	15.2	4.24	11.2	0.45	2.75	13.3
	–150	0.18	3.17	0.13	2.90	22.2	6.93	13.1	0.63	1.25	11.7
	–200	0.23	4.04	0.19	3.66	24.3	7.27	14.7	0.78	< 0.001	13.0
	–250	0.03	0.92	0.24	4.81	12.8	2.06	4.44	0.10	< 0.001	3.47
	–300	0.03	0.71	0.04	1.23	11.4	1.01	4.40	0.09	< 0.001	6.70

Profile	Depth, cm	Chemical element, g/kg								mmolc/100g	
		K_{NH_4Ac}	$K_{Aqua\ Regia}$	K_{AL}	K_{HCl}	$Fe_{Aqua\ Regia}$	$Fe_{Dit.citr.}$	$Al_{Aqua\ Regia}$	$Al_{Dit.citr.}$	Ac_{tot}	CEC_{tot}
PSM007190	–10	0.13	0.97	0.13	1.18	8.65	7.02	14.7	7.50	21.31	50.8
	–20	0.11	0.93	0.12	1.09	8.22	5.91	14.2	6.91	22.28	53.3
	–65	0.35	1.02	0.31	1.46	5.10	4.45	7.10	3.25	29.03	57.1
	–100	0.54	1.21	0.48	0.32	9.77	5.74	4.96	1.03	19.90	60.6
	–105	0.35	0.95	0.34	0.94	8.33	2.58	4.52	0.20	0.00	100.0
	–150	0.46	1.09	0.41	1.14	7.61	3.47	4.44	0.58	11.65	58.5
	–200	0.03	0.65	0.05	0.61	10.4	0.90	3.72	0.07	< 0.001	8.11
	–300	0.08	1.18	0.10	1.39	12.1	1.46	5.31	0.18	< 0.001	9.09