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Forsmark site investigation

Stratigraphical and analytical data of Quaternary deposits

Anna Hedenström
Geological Survey of Sweden

May 2004

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This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the author and do not necessarily coincide with those of the client.

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Abstract

This report includes the results from observations and analyses of Quaternary deposits from 17 sites within the Forsmark area. The report comprise stratigraphical descriptions and analytical data of grain size distribution and calcium carbonate content.

A majority of the observations and samplings were made the winter 2004 at the complementary installation of groundwater monitoring wells. Four samples collected the winter 2003 were included in the data set.

Several of the sites included in this activity are located in lakes. Samples of till beneath the lake sediment present valuable information on the spatial distribution of till within the Forsmark area. The till under Lake Bolundsfjärden and Lake Fiskarfjärden were sandy while the till under Lillfjärden was clayey. These observations are consistent to the till type on the shore close to the lakes. At the coring in Lake Gällsboträsket, on the contrary, boulder clay was retrieved at 4 m depth although the lake is located within an area with sandy till in the surface. The picture of a complex till stratigraphy in the area has been confirmed by the results from the present activity.

Percussion corings in the Börstilåsen esker confirmed a relatively thin deposit (c. 6 m) of sand and gravel with coarser sediment close to bedrock.

Analyses of calcium carbonate showed that all samples analysed contained CaCO_3 . The till samples had between 11 and 30 % while the lowest calcium carbonate content (5%) was recorded in a superficial sample of wave washed gravel.

Sammanfattning

Denna rapport redovisar resultaten från observationer och analyser av kvartära avlagringar från 17 lokaler inom Forsmarksområdet. Rapporten behandlar lagerföljdsbeskrivningar och analyser av kornstorleksfördelning och kalkhalt.

De flesta observationer och provtagningar utfördes i samband med kompletterande borrhningar för att installera grundvattenrör under vintern 2004. Analyser har även utförts på fyra arkiverade prover som togs under vintern 2003.

Många av lokalerna som redovisas i denna rapport är belägna i sjöar. Prover av morän under sjösedimenten tillför viktig information om hur de olika moränerna fördelas inom området. Under sjösedimenten i Bolundsfjärden och Fiskarfjärden ligger sandig morän och under sedimenten i Lillfjärden är moränen lerig sandig. Dessa analyser motsvarar moräntypen som finns i ytan närmast sjöarna. Vid borring under Gällsboträsket, som är beläget inom ett område med sandig och siltig morän, bestod provet däremot av moränlera. Den tidigare bilden av en komplex moränstratigrafi i området har bekräftats.

Hammarborringar i Börstilåsen bekräftar intrycket från ytkarteringen om en relativt tunn avlagring, cirka 6 meter djup, uppbyggd av sand och grus, med grövre sediment nedåt.

Analyser av kalkinnehåll i finfraktionen visade att samtliga prover innehöll CaCO_3 . Moränproverna hade mellan 11 och 30% CaCO_3 , medan den lägsta kalkhalten fanns i ett ytligt prov sandigt grus som innehöll 5% CaCO_3 .

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1 Introduction

This document reports results gained within the “Observations and analyses of Quaternary deposits”, one of the activities performed within the site investigation at Forsmark. The work was carried out in accordance with mini activity plan AP PF 400-04-12 and method description MD 131.001. The stratigraphical descriptions and sampling was performed in connection with drillings to install complementary groundwater monitoring wells and surface water level gauges and at percussion corings. The location of the sites included in this activity is shown in Figure 1-1. In Table 1-1 the controlling documents for performing this activity are listed and Table 1-2 gives the references to the data from the activity. Both activity plans and method descriptions are SKB’s internal controlling documents.

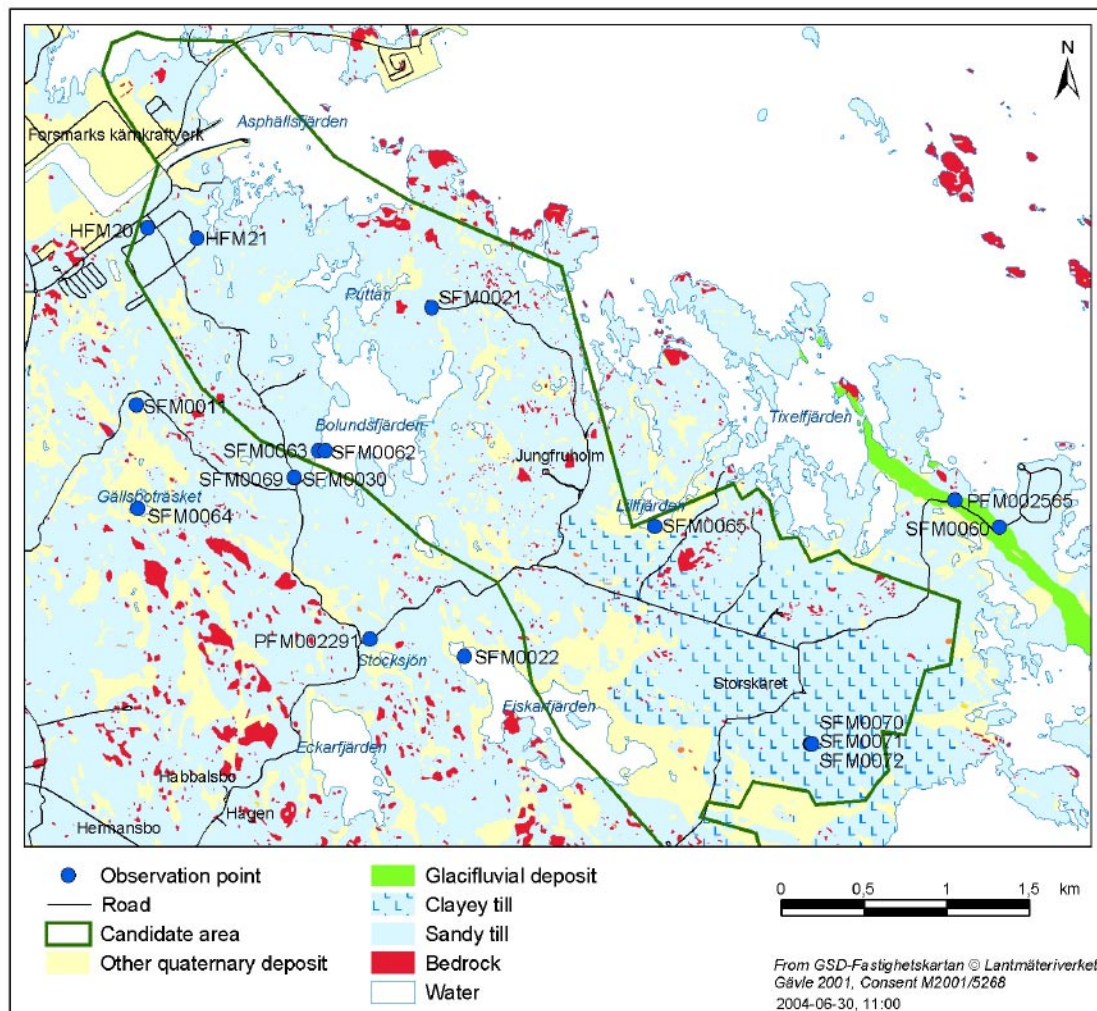


Figure 1-1. Map showing the sites where samples were collected and geological observations performed.

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

Activity plan	Number	Version
<i>Observationer och analyser av jordarter</i>	Mini AP PF 400-04-12	1.0
Method description	Number	Version
<i>Metodbeskrivning för jordartskartering</i>	SKB MD 131.001	1.0

Table 1-2. Data references.

Subactivity	Database	Identity number
Observations of Quaternary deposits, stratigraphical descriptions	SICADA	Field note no: Forsmark 284
Analytical results of grain size distribution and calcium carbonate content	SICADA	Field note no: Forsmark 284

2 Objective and scope

The mapping of unconsolidated Quaternary deposits lasted during the field seasons 2002 and 2003. The investigations included regular mapping of the superficial Quaternary deposits, presented in a geological map /Sohlenius et al. 2004/. Furthermore, analytical and stratigraphical data collected during 2002 was reported by Sohlenius & Rudmark /2003/. Stratigraphical information of the Quaternary deposits was investigated in machine cut trenches /Sundh et al. 2004/ and at corings /Hedenström et al. 2004/. The present activity was initiated after the mapping of Quaternary deposits was completed and focuses on collecting information of the Quaternary deposits, derived primary from other activities within the site investigations. The present report presents stratigraphical information and results from the analyses of grain size distribution and calcium carbonate.

Laboratory analyses were carried out on selected samples in order to characterise the physical properties of the unconsolidated Quaternary deposits. Complementary analyses of samples collected 2003 were performed after consultation with the Forsmark surface hydrogeologist, Per-Olov Johansson. The analytical data will be useful for the hydrogeological modelling and for the conceptual understanding of the Quaternary geological evolution of the area. The stratigraphical information will also be valuable in the construction of a 3-dimensional model of the unconsolidated Quaternary deposits in the Forsmark area.

3 Equipment

3.1 Description of equipment/interpretation tools

The equipment used for corings is described in detail in the reports from the activities in which they were performed /Johansson 2003, Werner & Lundholm 2004, Werner et al. 2004/. The investigations of lake sediment was performed using a Russian peat corer /Hedenström 2003/.

4 Execution

4.1 General

This report includes information on the textural analyses and stratigraphical descriptions of unconsolidated Quaternary deposits obtained e.g. from drillings at the installation of complementary groundwater monitoring wells during the winter 2004. Further more, geological information from percussion corings is included in the activity. The methods used for describing the samples, as well as the analyses, are according to method description for mapping of unconsolidated Quaternary deposits, SKB MD 131.001 (SKB internal document).

4.2 Execution of field work

The coring techniques applied to obtain the samples are described by Johansson 2003, Werner et al. 2004 and Werner & Lundholm 2004.

The sampling of till beneath the lakes was performed using a hand-held Berema Pionjär (Figure 4-1). Sampling of the till was performed by flushing, using lake water. This process probably reduces the content of fine fractions in the samples.



Figure 4-1. Leif Lundholm, Sweco VBB Viak, performed the sampling of till from beneath the lakes by flushing the sediment.

4.3 Data handling/post processing

The geological information connected to the PFM, SFM and HFM numbers were stored in a data base for mapping of unconsolidated Quaternary deposits at the Geological Survey of Sweden (Jorrdagboken, Version 5.4.3). The data were subsequently exported to SICADA (Field note no: Forsmark 284).

The following data have been exported to SICADA

- Geological observations and stratigraphical descriptions (9 sites)
- *Results from grain size and CaCO₃ analyses (13 samples)*
- *Graphs showing the grain size distribution curves (13 samples)*

4.4 Analyses and interpretations

The litho-stratigraphy from the drillings was described directly in the field and samples were selected for grain size and calcite analyses. Samples collected but not analysed, together with dried residuals of analysed samples, are stored at SKB (Forsmark).

Grain size analyses on material <20 mm were carried out on 13 samples at SWECO, Geolab in Stockholm. The grain size distribution of coarse material (20-0.063 mm) was determined by sieving and finer material (<0.063 mm) with a hydrometer. The content of CaCO₃ was determined (SWECO, Geolab) on the same 13 samples (grain sizes <0.063 mm) using Passons apparatus (Talme and Almén 1975). The colour of the sediment was classified according to standard soil colour charts by Munsell /1994/. The analytical data is stored in the SKB SICADA database under Field note no: Forsmark 284.

4.5 Nonconformities

The work was performed without any nonconformities according to mini AP PF 400-04-12 (SKB controlling document).

5 Results

Simplified stratigraphical descriptions are listed in Appendix 1 and a summary of the grain size and calcium carbonate analyses are listed in Table 5-1. Graphs showing the grain size distribution curves are presented in Appendix 2. The location of the sites included in this activity is showed in Figure 1-1, plotted on the Quaternary geological map. Geotechnical descriptions and logs from the corings are presented by Werner & Lundholm /2004/ and Werner et al. /2004/.

Complementary analyses

Four samples collected 2003 were selected with the purpose to characterise the physical properties of the Quaternary sediments at levels where complementary groundwater monitoring wells have been installed /Werner & Lundholm 2004/. The samples collected 2003 are marked * in Table 5-1.

Table 5-1. Summary of the results from analyses of grain size distribution and calcium carbonate.

Idcode	Sample nr	Secup (m)	Seclow (m)	Quaternary deposit	Colour (Munsell)	CaCO₃ (%)
SFM0011*	1	0,5	1,3	Clayey sandy till	5Y5/2	23
SFM0021*	1	0,4	0,9	Clayey sandy till	5Y5/3	30
SFM0022	1	4,0	4,6	Sandy till	5Y4/2	12
SFM0030*	1	0,6	1,05	Sandy till	5Y5/3	21
SFM0030*	2	1,4	1,7	Sandy till	5Y5/3	18
SFM0062	3	2,75	3,15	Sandy till	5Y5/3	11
SFM0063	2	2,1	2,9	Sandy till	10YR4/2	11
SFM0064	2	4,4	4,4	Boulder clay	2,5Y5/2	24
SFM0065	5	3,7	4,0	Clayey sandy till	5Y5/2	30
SFM0069	1	0,3	0,7	Sandy gravel	10YR3/2	5
SFM0070	1	1,4	1,65	Clayey sandy silty till	5Y4/3	22
SFM0071	1	3,25	3,5	Boulder clay	5Y4/2	24
SFM0072	1	8,2	8,7	Clayey sandy silty till	5Y4/2	26

* = The sample was collected during the field campaign 2003 /Johansson 2003/.

Till under lakes

The analyses of till collected from under the lake sediments showed that sandy till is located beneath the northern part of Lake Fiskarfjärden (SFM0022) and the southwestern part of Lake Bolundsfjärden (SFM0062 and SFM0063) while the till under Lake Lillfjärden is clayey sandy (SFM0065). This shows that, at least at the analysed levels and sites, the till in the surface close to the coring points continues under the lakes /cf. Figure 1-1/.

One sample was analysed from the till under Lake Gällsboträsket (SFM0064), which is located within the area with sandy and silty till in the surface (Figure 1-1). Under a layer of hard till, or possibly a stone (Figure 5-1), a sample was collected at 4.4 m depth. The sample was analysed as boulder clay (Table 5-1, Appendix 2). This indicates that the complex till stratigraphy observed at e.g. corings east of Lake Eckarfjärden (SFM0016 in Hedenström et al. 2004) and a machine cut trench north of Lake Gällsboträsket (PFM002581 in Sundh et al. 2004) also is present within this area. It should be noted that the samples collected by flushing the sediment may have been reduced on its fine fractions, or the samples may have been contaminated by lake sediments during the sampling process (cf. Figure 1-1).



Figure 5-1. Leif Lundholm and Patrick Smützer from Sweco VBB Viak, sampling at Lake Gällsboträsket. At c. 3 m depth, the till was very hard and could not be penetrated without the extra power from Kenneth Åkerström (to the right in the picture).

The Börstilåsen esker

The corings at SFM0060 and PFM002565 give valuable stratigraphical information from the Börstilåsen. Since the esker is located within the Kallriga nature reserve, possibilities for corings and excavations are very restricted. The thickness of the glaciofluvial deposits was only one meter at PFM002565 and 6.8 m at SFM0060. This indicates that the esker is decreasing in volume towards the northwest which is confirmed by the geological map /Sohlenius et al. 2004/. No analysis has yet been performed on the glaciofluvial sediment. The field classification of the samples from the percussion coring revealed gravely sand in the upper part and a coarser sediment downward (Figure 5-2, Table 5-1).



Figure 5-2. Percussion coring at SFM0060 at the Börstilåsen esker. The glaciofluvial sediment was sandy gravel at the surface and coarser gravel further down. The sediment in the foreground (gravel) is exposed in an old gravel-pit.

Depth to bedrock

Information of the depth of the Quaternary cover was obtained from the corings. The coring performed at PFM002991 was initiated as an extra check of the depth to bedrock as recorded at SFM0019 (4.8 m, Johansson 2003). The reason for this check was the results from reconstruction of soil depth based on seismic profiles /Bergman et al. in progress/. The seismic profile showed a depression in the bedrock, and a corresponding thick soil-cover north of Lake Stocksjön and close to SFM0019. Furthermore, there were indications that bedrock was not reached at the coring of SFM0019 since fragments of Palaeozoic limestone occurred in the sample of supposed crystalline bedrock fragments /Hedenström et al. 2004/. At the coring of PFM002991, the bedrock was reached at approximately the same depth as at SFM0019 (5.8 m). The reason for the occurrence of limestone in the bedrock sample at SFM0019 may be contamination from the overlying till.

The two percussion bore holes HFM20 and HFM21 located in the north-western part of the Forsmark candidate area uniformly showed a c. 3 m thick layer of sandy till covering the bedrock.

Calcium carbonate content

All samples analysed contained calcium carbonate (Table 5-1). One sample of wave washed sandy gravel (SFM0069), collected at 0.3-0.7 m depth contained 5% CaCO₃. The additional twelve till samples analysed contained between 11 and 30 % CaCO₃. These values are consistent with earlier analyses from the area /e.g. Sundh et al. 2004, Hedenström et al. 2004/.

Summary

The results gained within the present activity are consistent to the over-all knowledge of the unconsolidated Quaternary deposits in the Forsmark area /e.g. Sohlenius et al. 2003; 2004, Sundh et al. 2004, Hedenström et al. 2004/.

Crucial new information obtained from this activity is the samples of till collected from underneath four of the lakes. Since lakes cover large areas of the surface and the till stratigraphy in the area is complex, these few scattered samples can not serve as reference for the entire lake areas.

The percussion corings at the Börstilåsen esker reviled 6.8 m and 1 m glaciofluvial sediment at two corings. These corings confirm the impression from the surface that the Börstilåsen esker in this area is thin and decreases further towards the northwest.

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Simplified stratigraphical descriptions based on field classifications, together with the results from grain size analyse.

ID code	Secup (m)	Seclow (m)	Field classification	Lab classification
HFM20	0,00	1,50	Artificial fill	
	1,50	3,00	Gravelly sandy diamicton	
HFM21	0,00	1,00	No sample retrieved	
	1,00	1,50	Sandy diamicton, wave washed	
	1,50	2,00	Sandy diamicton	
	2,00	3,10	Sandy diamicton, silty downward	
PFM002291	0,00	0,60	Sandy diamicton, wave washed	
	0,60	1,00	Sandy diamicton, hard	
	1,00	5,80	Sandy diamicton	
	5,80	7,00	Bedrock fragments	
PFM002565	0,00	1,00	Glaciofluvial sediment	
	1,00	3,00	Bedrock fragments	
SFM0022	0,00	0,62	Water	
	0,62	1,00	Gyttja	
	1,00	1,54	Algal gyttja	
	1,54	1,86	Algal gyttja	
	1,86	2,65	Clay gyttja	
	2,55	2,58	Silty sand	
	2,57	2,72	Glacial clay	
	2,72	2,80	Gravelly sand	
	2,80	4,80	Sandy diamicton	Sandy till
SFM0060	0,00	1,20	Gravelly sand	
	1,20	3,00	Boulder	
	3,00	3,70	Sandy gravel	
	3,70	6,80	Gravel	
SFM0062	0,00	0,61	Water	
	0,61	0,80	Not classified	
	0,80	1,00	Algal gyttja	
	1,00	3,15	Sandy silty diamicton	Sandy till
SFM0063	0,00	0,75	Water	
	0,75	1,25	Algal gyttja	
	1,25	3,10	Sandy diamicton	Sandy till
SFM0064	0,00	0,80	Water	
	0,80	1,30	Algal gyttja	
	1,30	2,10	Clay gyttja	
	2,10	2,15	Sand	
	2,15	3,00	Glacial clay	
	3,00	4,55	Diamicton	Boulder clay
SFM0065	0,00	0,36	Water	
	0,36	0,51	Not classified	

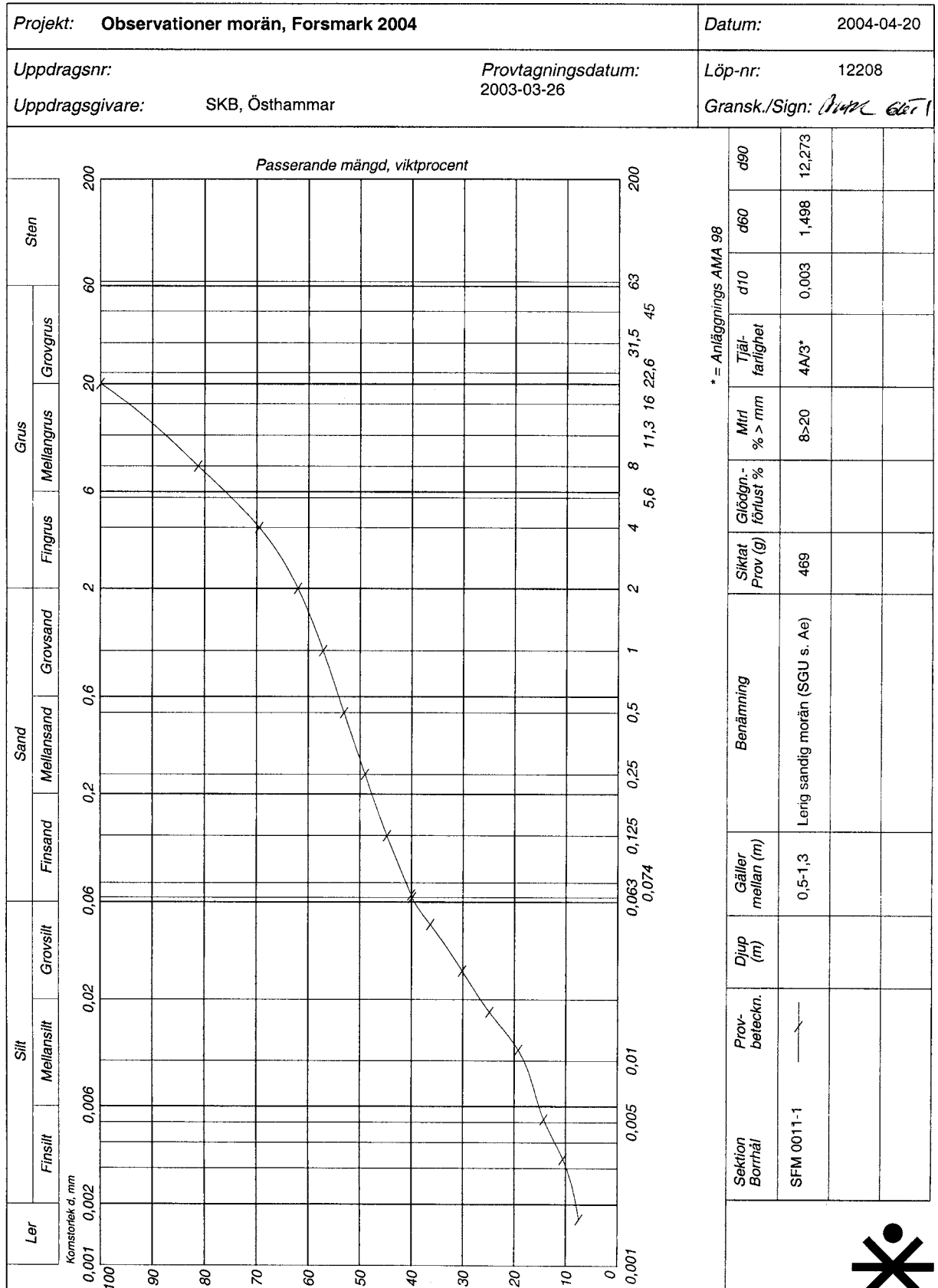
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	0,70	0,95	Gravelly sand	
	0,95	1,25	Clay	
	1,25	1,45	Gravelly sand	
	1,45	1,55	Clayey diamicton	
	1,55	4,00	Diamicton, unspecified	Clayey sandy till

Grain size distribution curves

Kornfördelning

enl. SS027123 och SS027124

SWECO GEOLAB



SWECO GEOLAB, Ingår i SWECO VBB AB

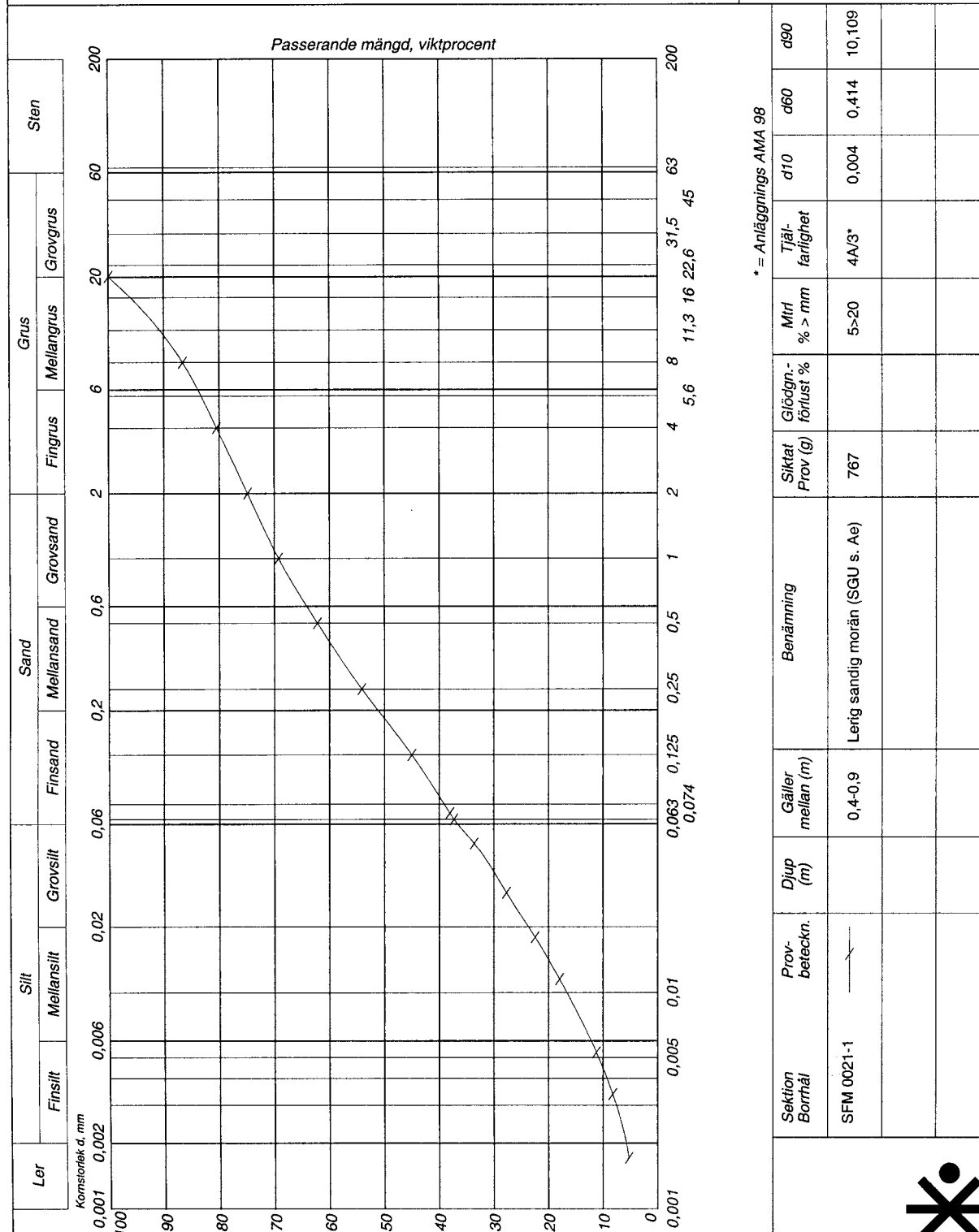
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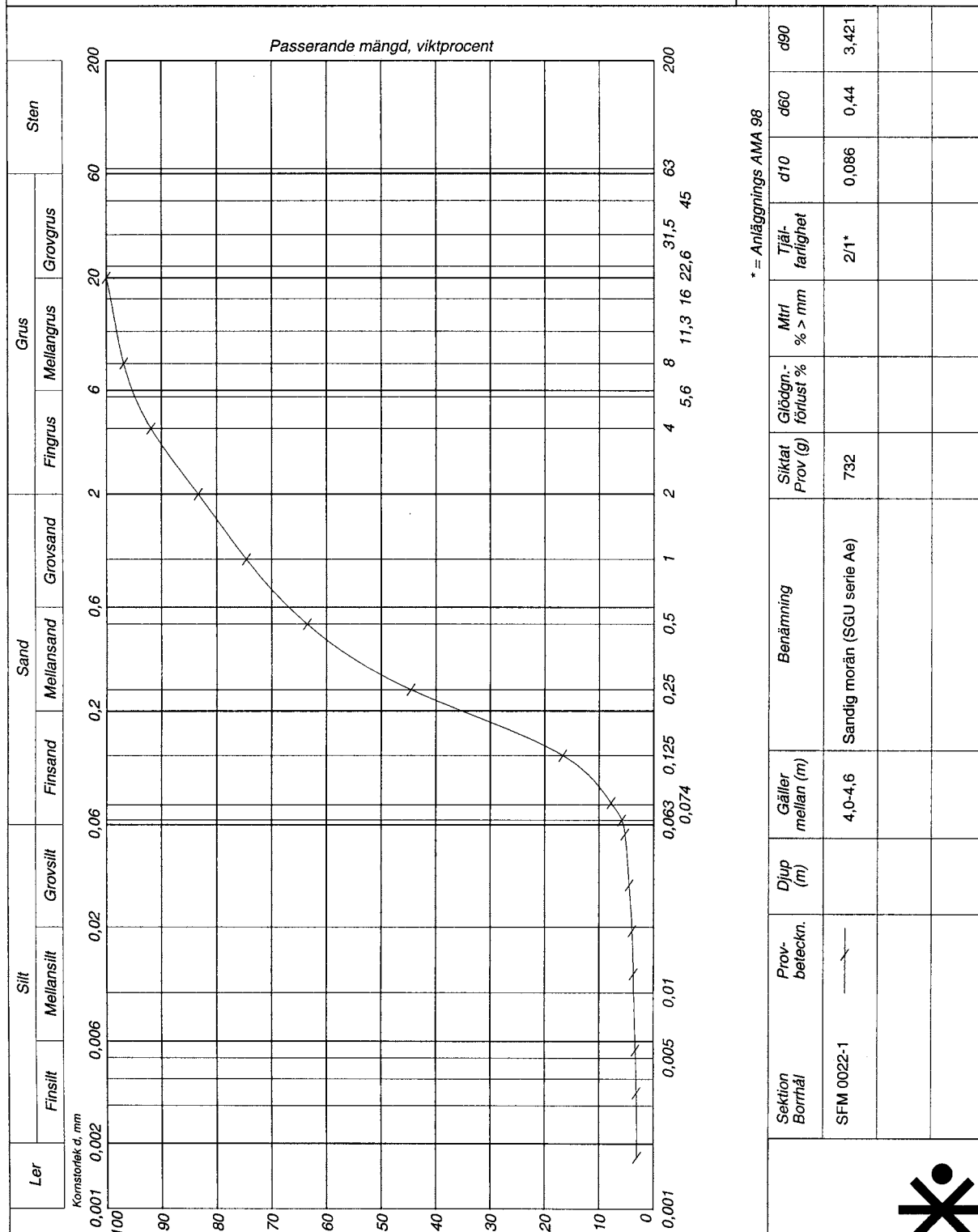
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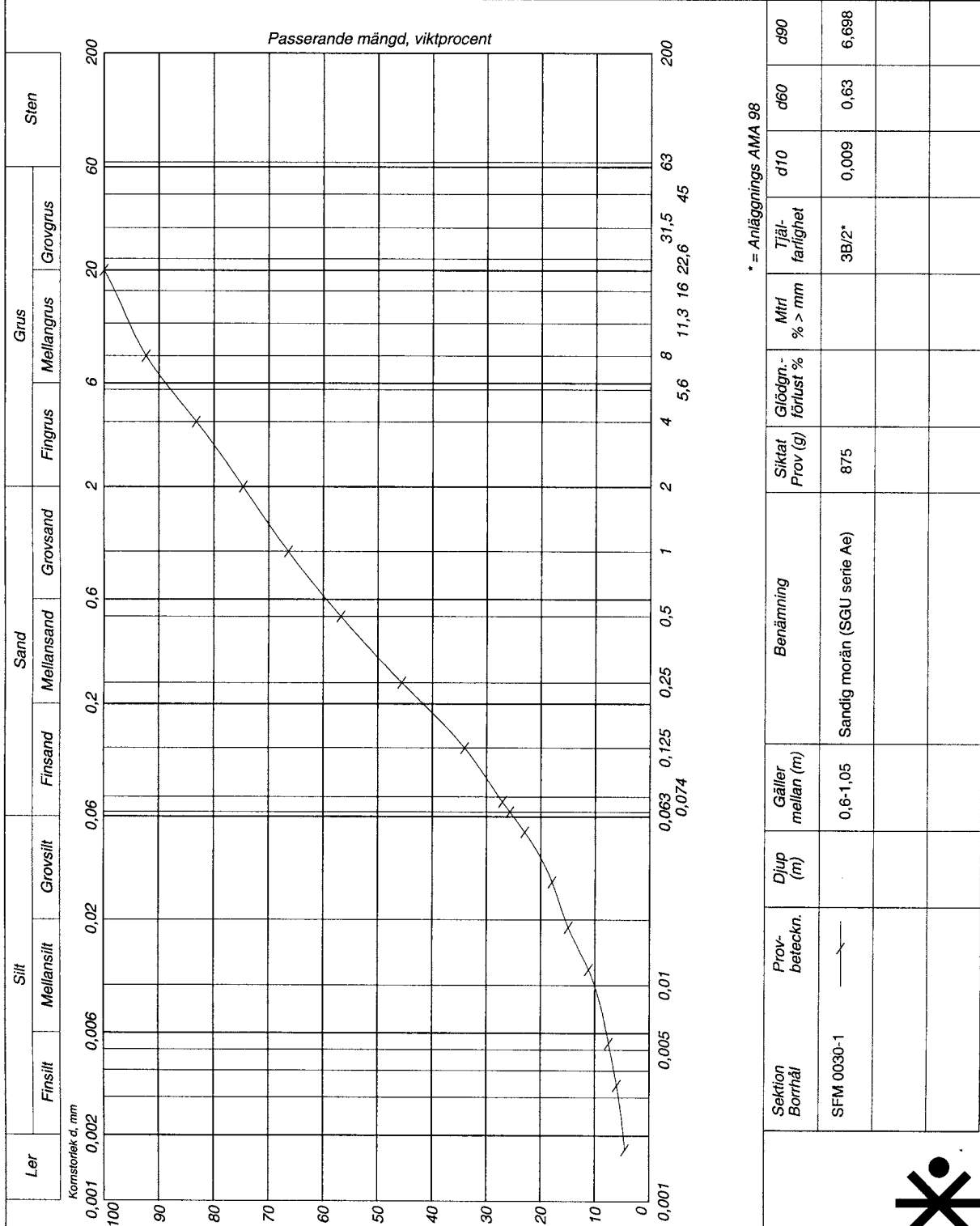
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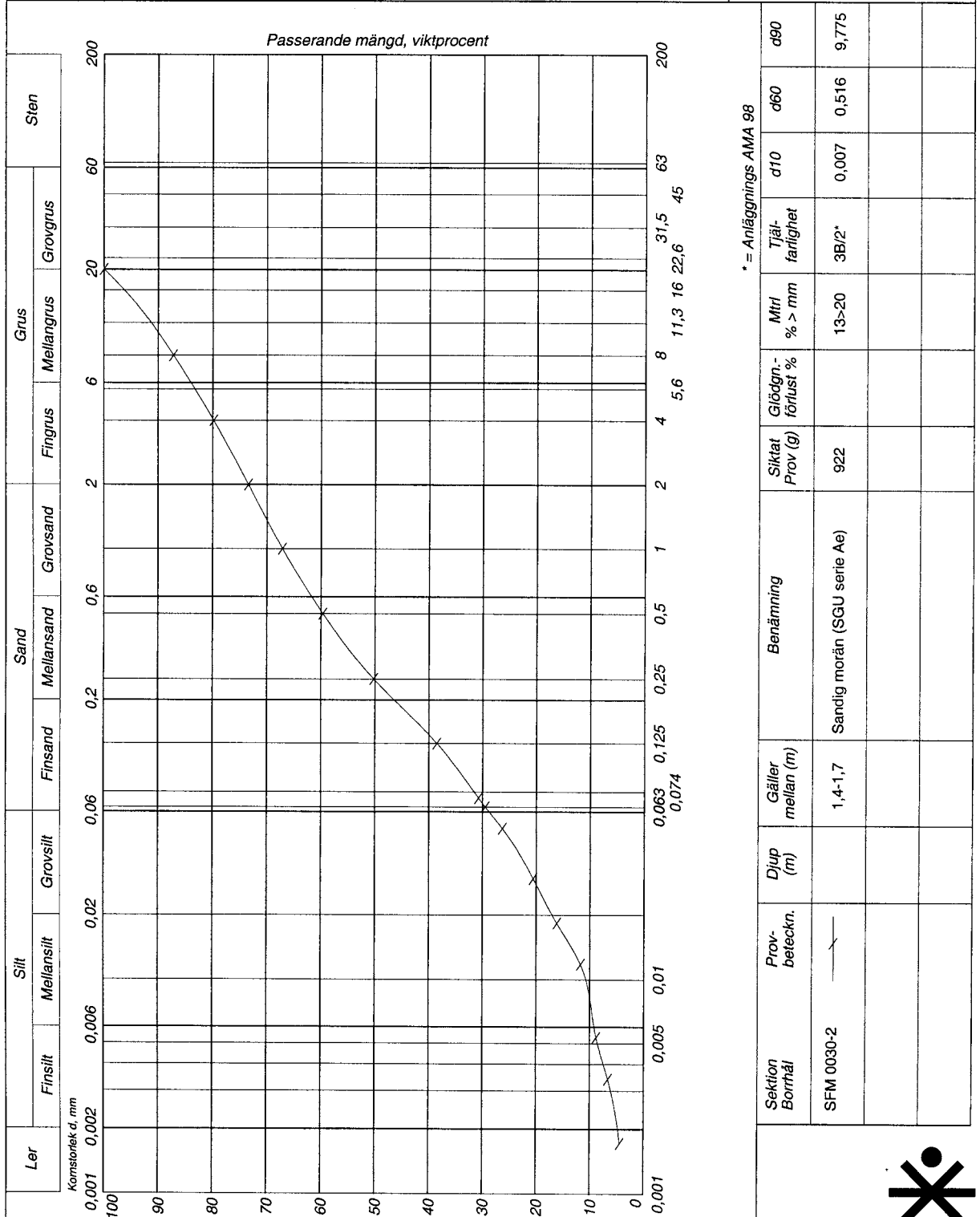
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	Gransk./Sign: <i>Mark Gull</i>



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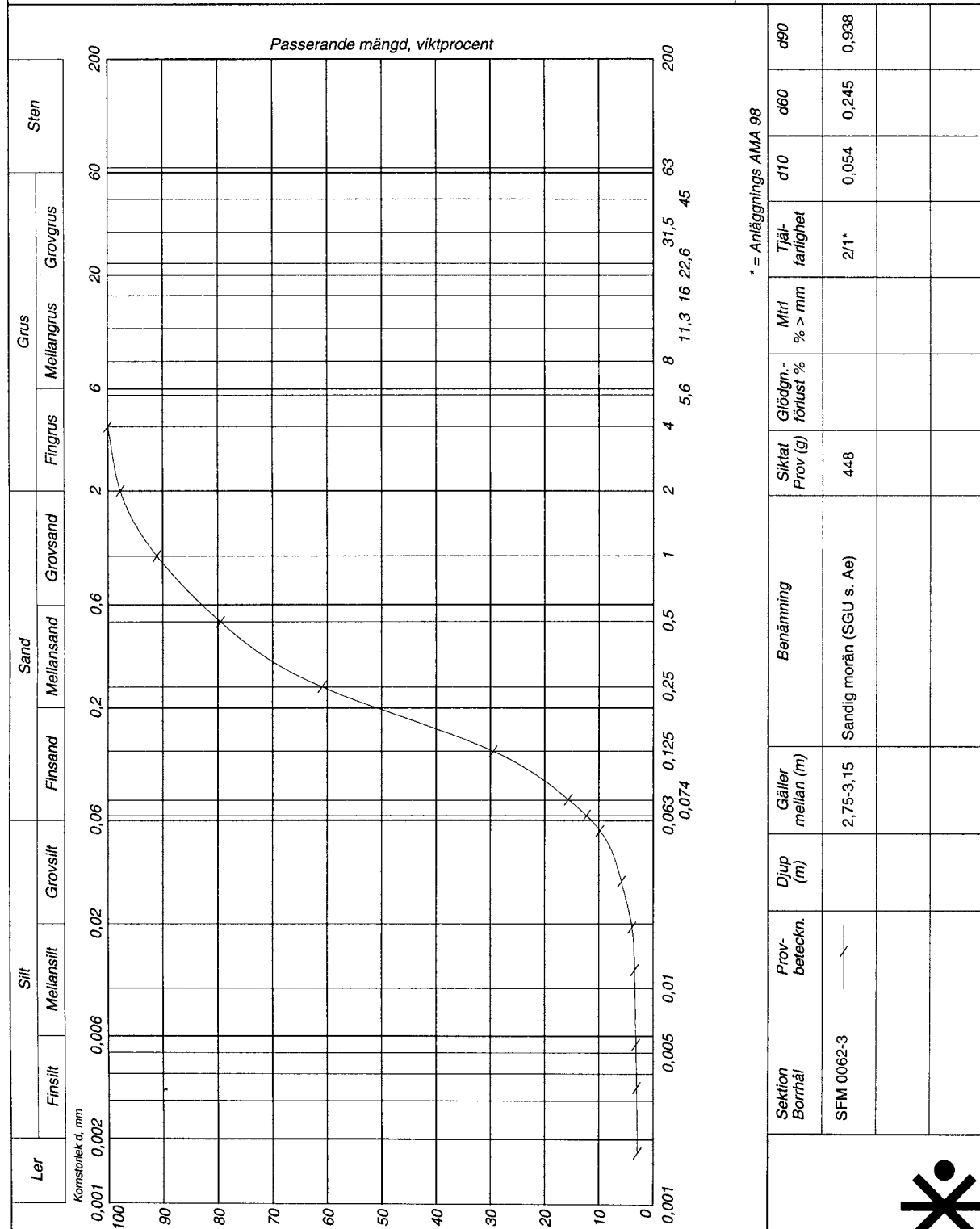
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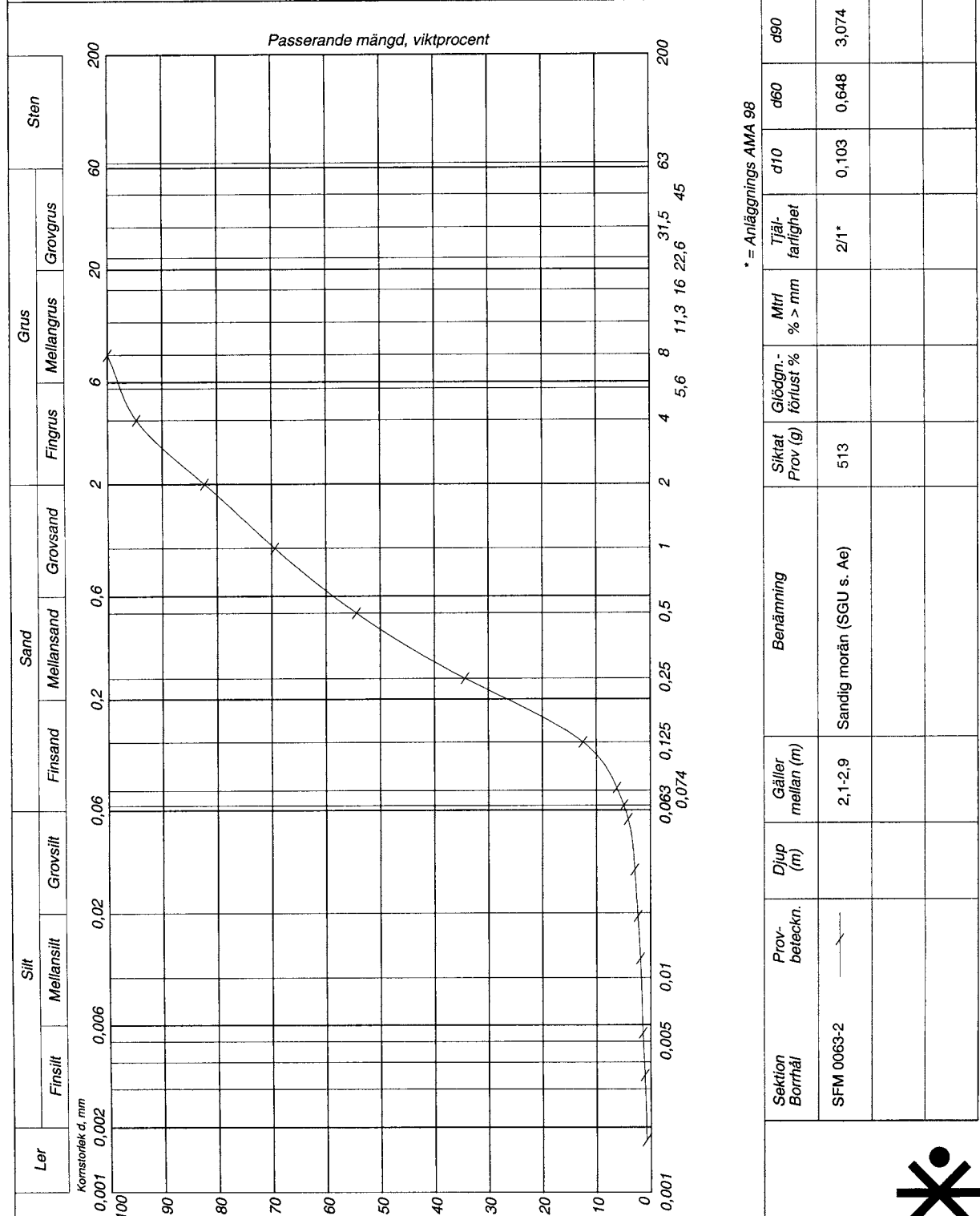
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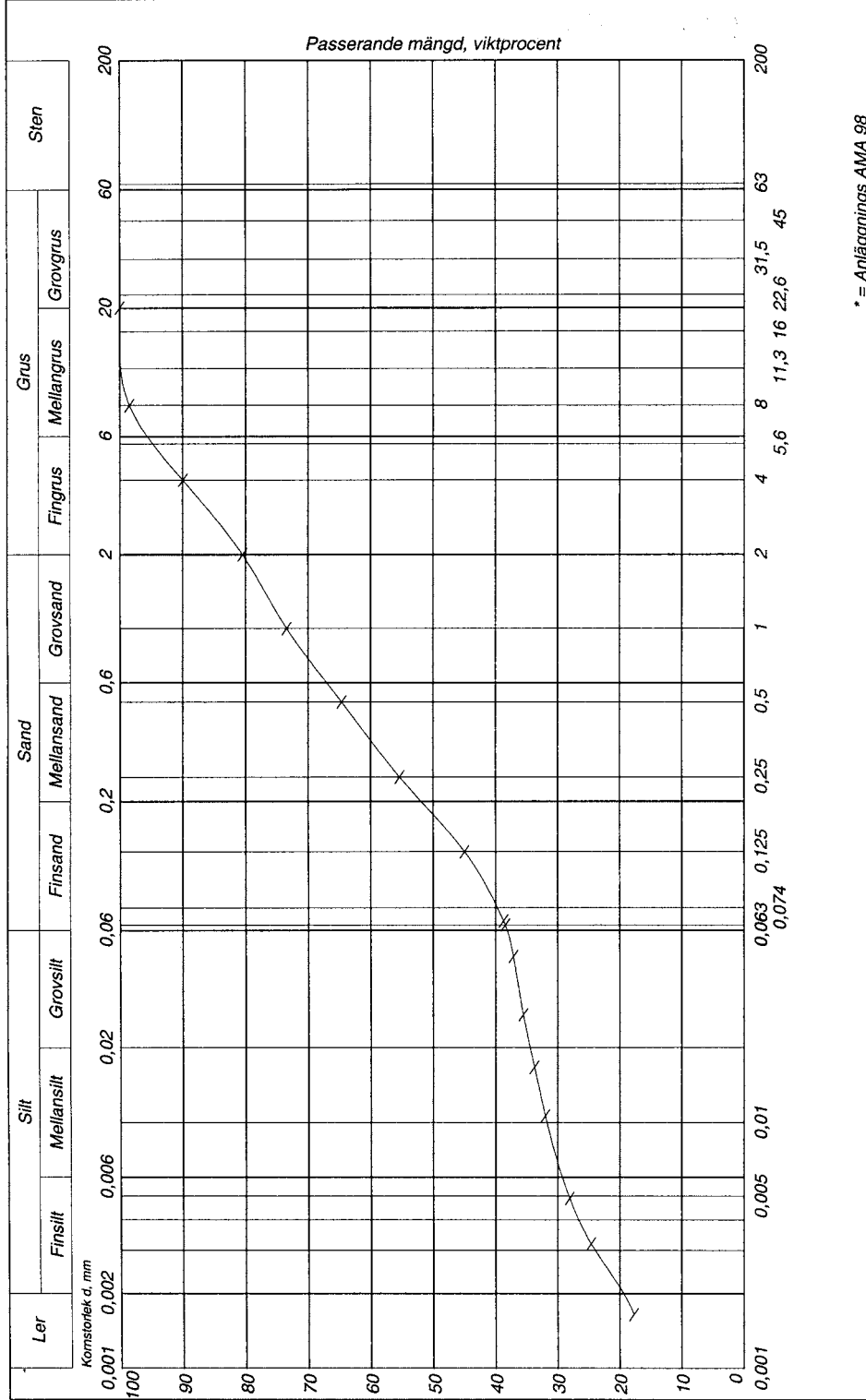
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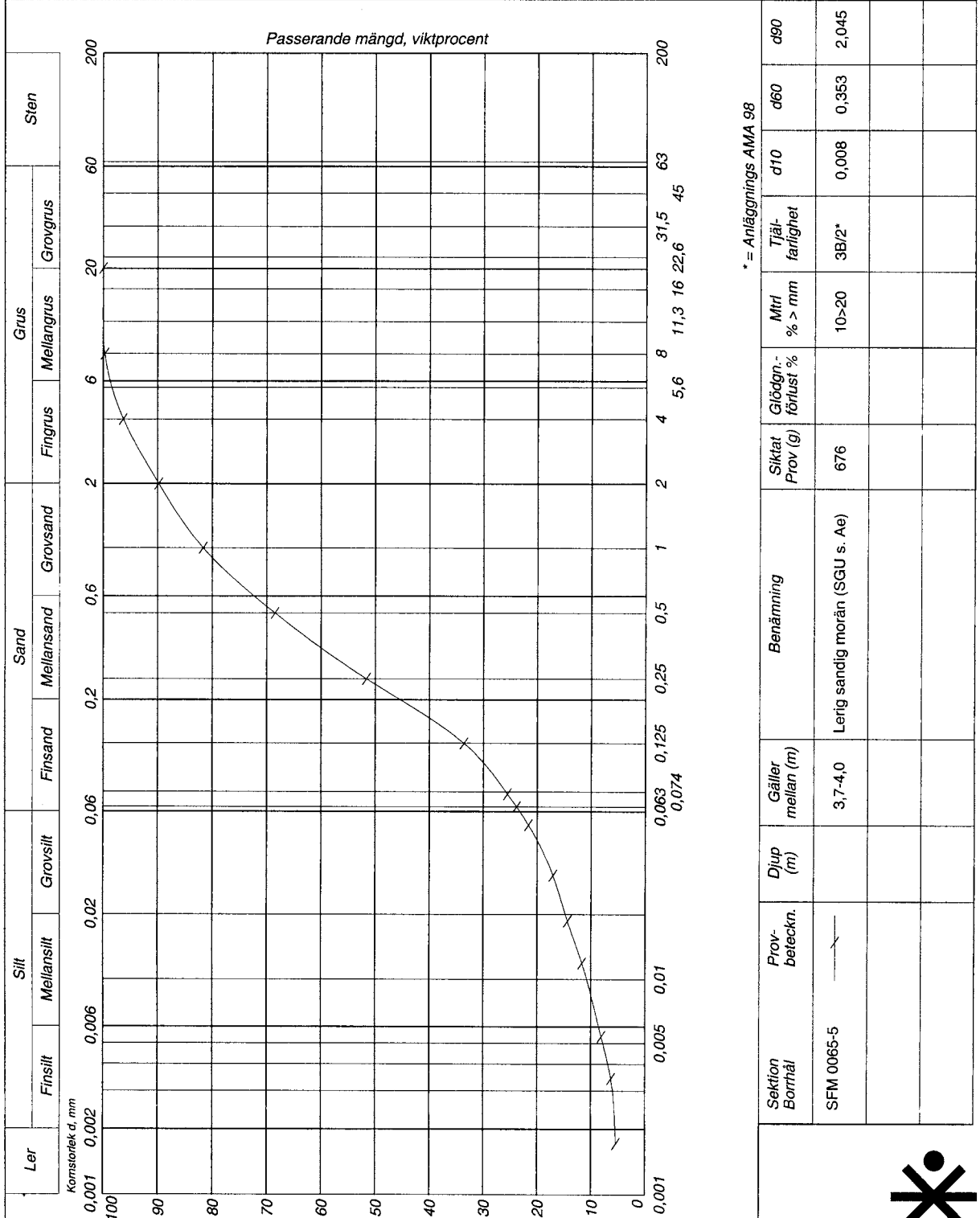
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SFM 0064-2		4,4	Moränlera (SGU serie Ae)	399	4A3*	0,353	4,008				

* = Anläggnings AMA 98

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Tel: 08-695 60 00 Fax: 08-695 63 60 E-mail: geolab@sweco.se; www.sweco.se/geolab



Projekt: Observationer morän, Forsmark 2004		Datum: 2004-04-21
Uppdragsnr:	Provtagningsdatum: 2004-02-06	Löp-nr: 12208
Uppdragsgivare: SKB, Östhammar		Gransk./Sign: <i>AMA G411</i>



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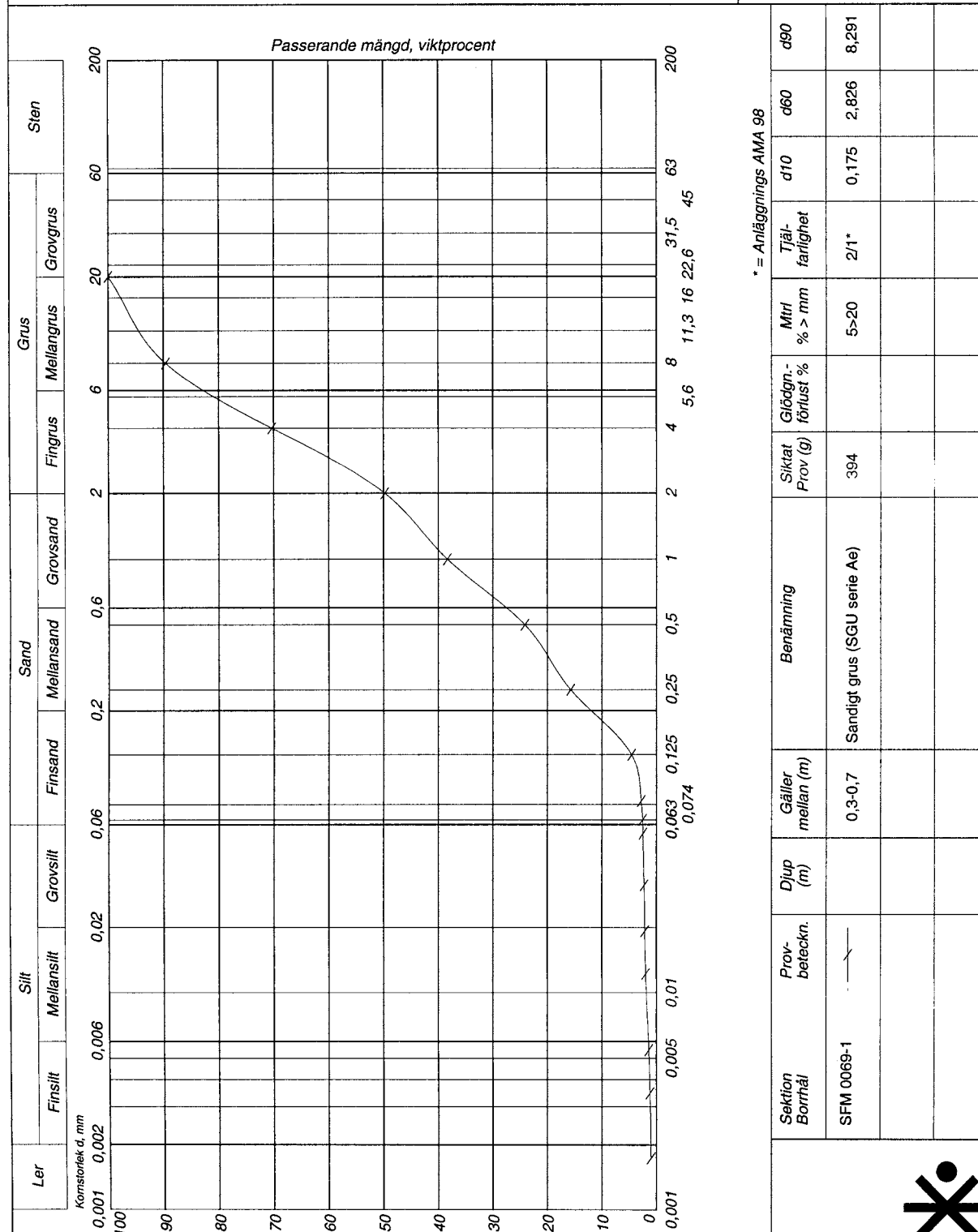
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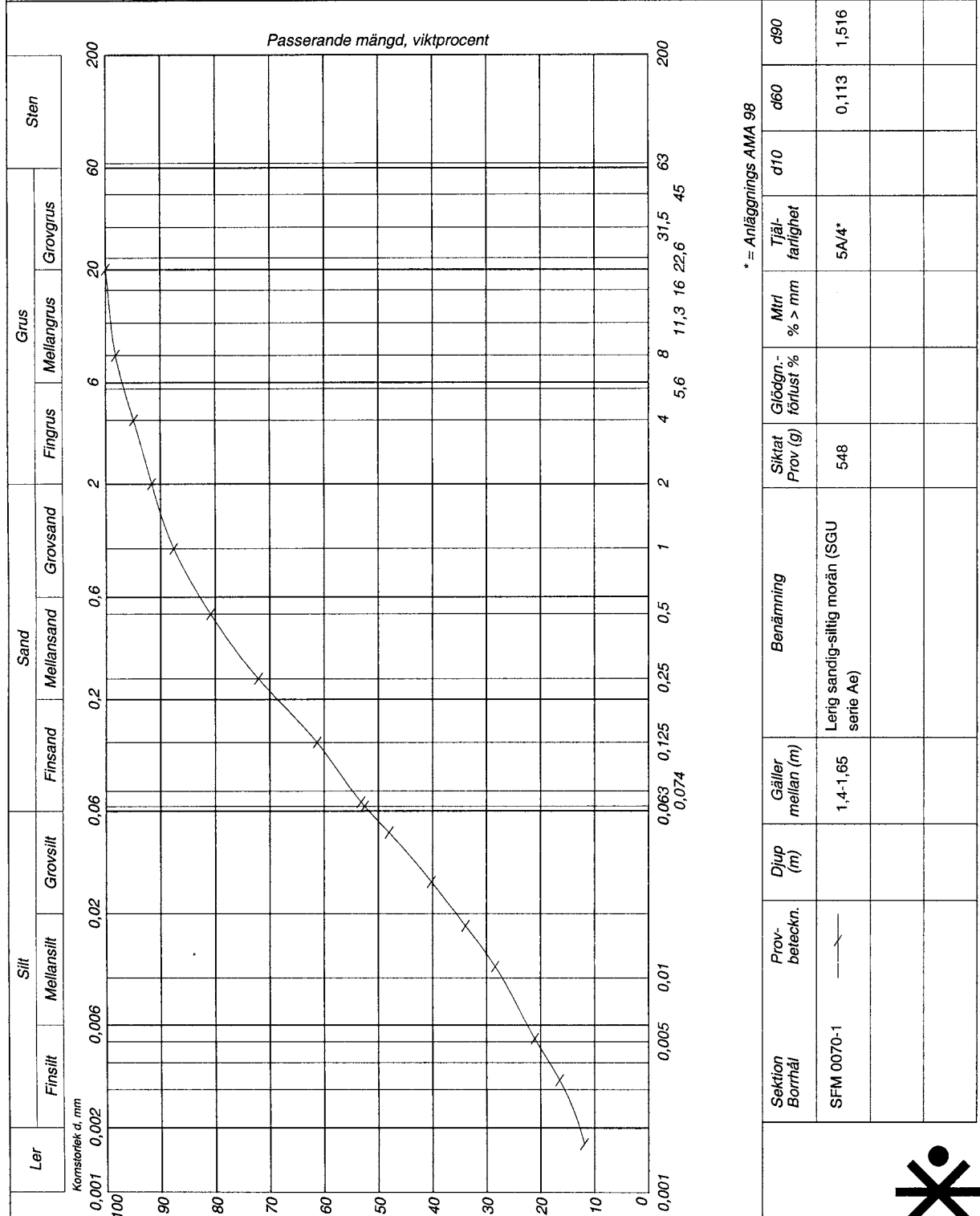
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Uppdragsnr: Uppdragsgivare: SKB, Östhammar	Provtagningsdatum: 2004-03-29 Löp-nr: 12208 Gransk./Sign: <i>AMA GWT</i>



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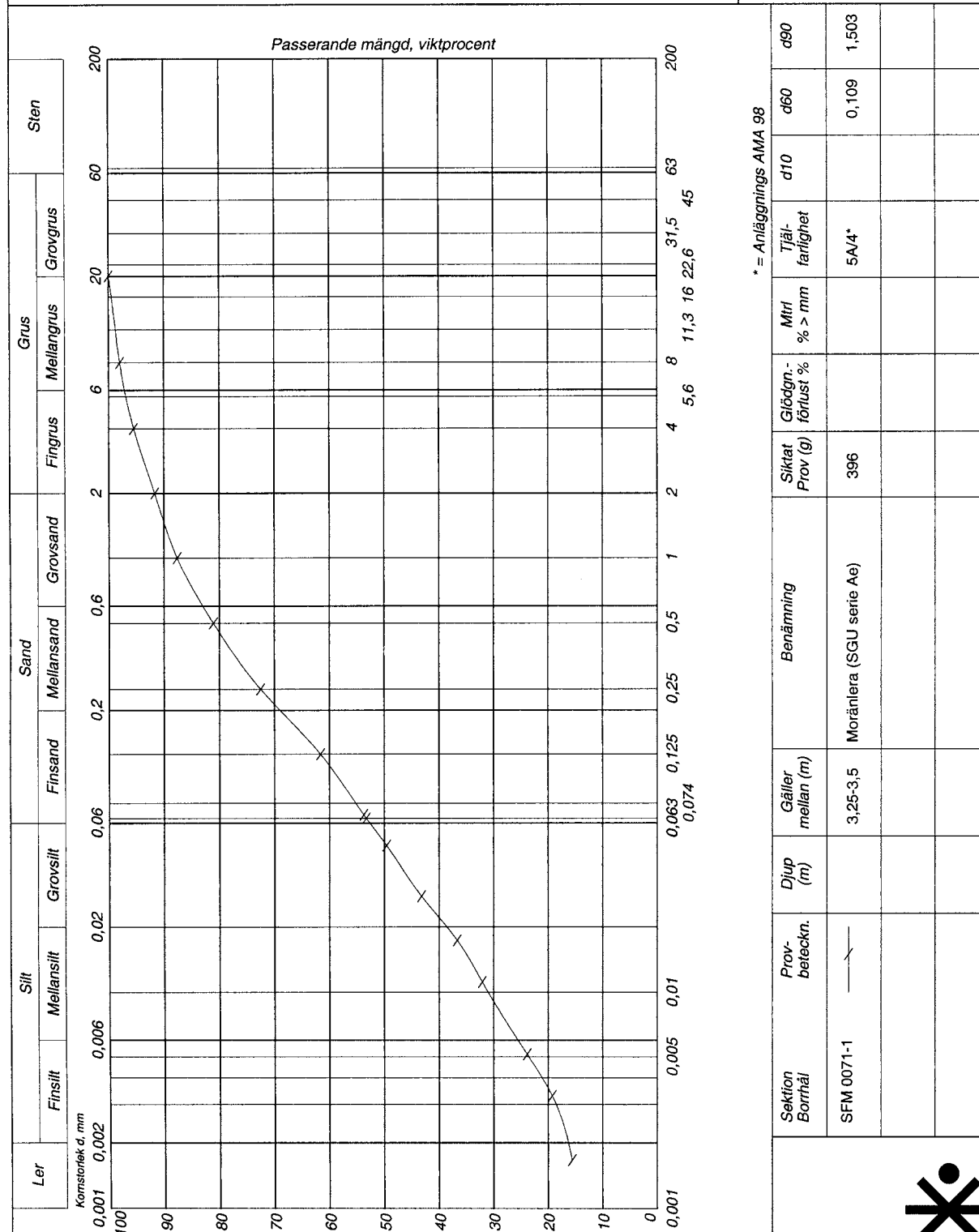
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Uppdragsnr:	Provtagningsdatum: 2004-03-25
Uppdragsgivare: SKB, Östhammar	Löp-nr: 12208
	Gransk./Sign: <i>[Signature]</i>



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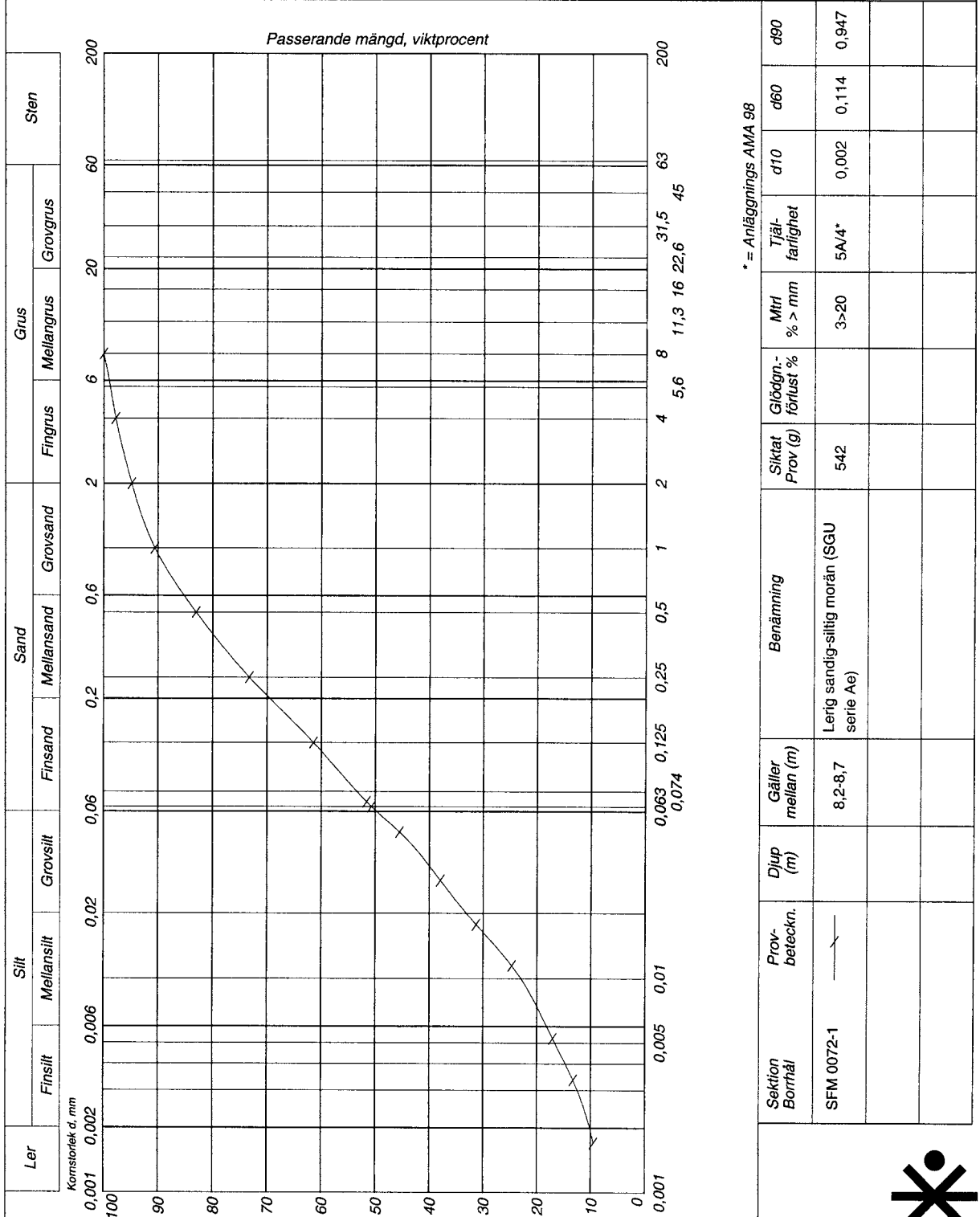
Projekt: Observationer morän, Forsmark 2004	Datum: 2004-04-21
Uppdragsnr: 2004-03-25	Provtagningsdatum: 2004-03-25
Uppdragsgivare: SKB, Östhammar	Löp-nr: 12208
	Gransk./Sign: <i>DMK GUT</i>



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Projekt: Observationer morän, Forsmark 2004	Datum: 2004-04-21
Uppdragsnr:	Provtagningsdatum: 2004-03-25
Uppdragsgivare: SKB, Östhammar	Löp-nr: 12208
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