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Oskarshamn site investigation

Refraction seismic measurements in Laxemar autumn 2004

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December 2004

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Keywords: Refraction seismics, Bedrock velocity, Soil velocity, Soil depth, Overburden, Laxemar.

Abstract

This document reports the execution and interpretation of refraction seismics performed in Laxemar during October–November 2004. All measurements were conducted by MRM Konsult AB.

The main objective of the investigation was to investigate the soil depth in order to find the most suitable locations for digging trenches to expose the rock surface for geological mapping. Another objective was to investigate possible tectonic lineaments predicted by different geological and geophysical methods.

Five profiles with a total length of 2,880 m were measured. The survey lines were placed to cross over the soil covered part of the Laxemar area where the bedrock not was exposed. The soil cover varied between 0 and 9.2 m with a mean value of 3.6 m. Some zones with a lower velocity in the range between 3,500 and 4,100 m/s where found. The bedrock velocity was generally high between 5,200 and 5,600 m/s and even up to 5,900 m/s. The mean value of the bedrock velocity for compact rock is 5,462 m/s.

Sammanfattning

Rapporten presenterar utförandet och resultat av tolkningen av refraktionsseismik som genomfördes i Laxemar under oktober–november 2004. Mätningarna genomfördes av MRM Konsult AB som också genomförde tolkningen.

Huvudsyftet med undersökningarna var att undersöka jorddjupet inför planerad grävning av diken och gropar för friläggning av berget för att kunna genomföra geologisk kartering. Ett annat syfte var att undersöka möjliga tektoniska lineament identifierade med olika geologiska och geofysiska metoder som ligger dolda av jordtäcket.

Fem profiler med en total längd av 2 880 m undersöktes. Undersökningslinjerna placerades för att korsa det jordtäckta området i Laxemar där berggrunden inte är exponerad. Jorddjupet varierar mellan 0 och 9,2 m med ett medelvärde på 3,6 m. Några zoner med något lägre utbredningshastighet i berget, från 3 500 m/s upp till 4 100 m/s indikerades. Utbredningshastigheten i friskt berg varierade mellan 5 100 m/s upp till 5 600 m/s och till och med ända upp till 5 900 m/s. Medelvärdet på utbrednings-hastigheten i friskt berg är 5 462 m/s.

Contents

1 Introduction

This document reports the results gained by the measurements and interpretation of refraction seismics in Laxemar subarea, which is one of the activities performed within the site investigation at Oskarshamn. The work was carried out in accordance with activity plan AP PS 400-04-092. In Table 1-1 the controlling documents for performing this activity are listed. Both activity plan and method descriptions are SKB's internal controlling documents.

Five profiles with a total length of 2,880 m were measured. The survey lines were placed to cross over the soil covered part of the Laxemar area where the bedrock not was exposed. The location of the survey lines is shown in Figure 1-1.

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

Activity plan	Number	Version
Refraktionsseismik I Laxemar.	AP PS 400-04-092	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för refraktionsseimik.	SKB MD 242.001	1.0

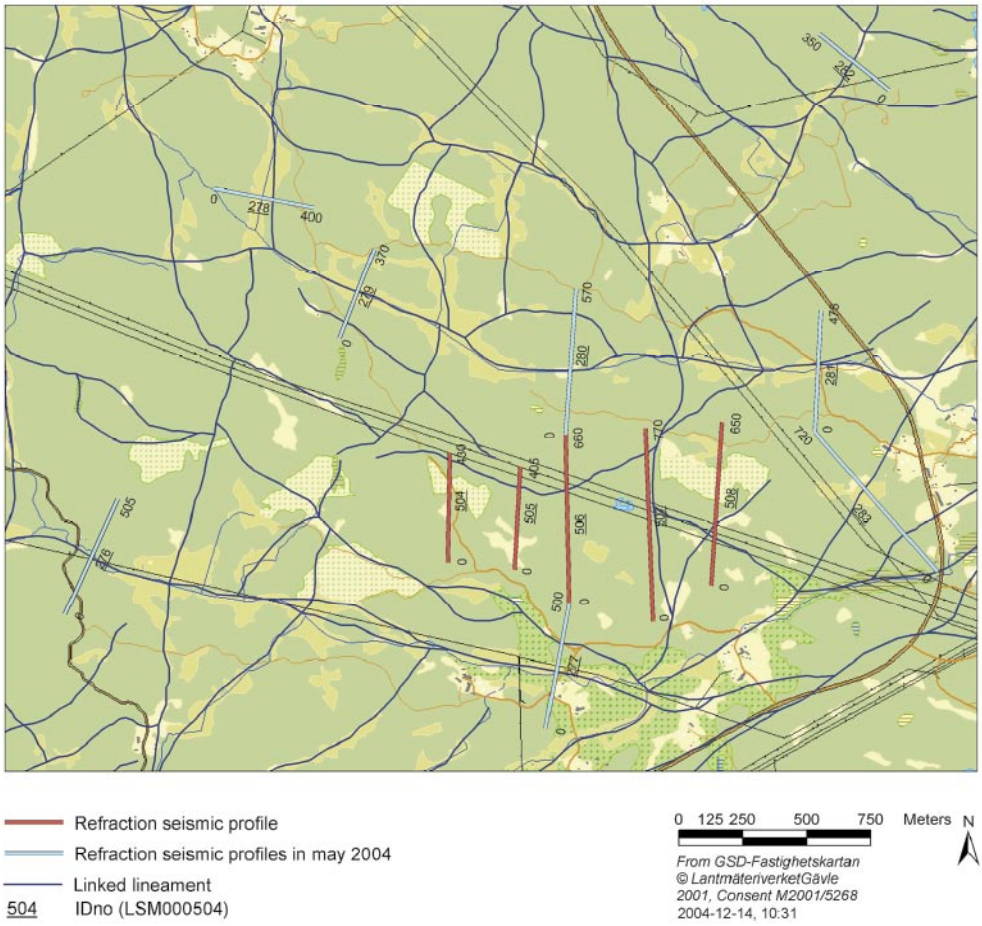

Figure 1-1. *Location of refraction seismic profiles in Laxemar subarea.*

All data has been inserted in the SICADA database. The corresponding field note no is listed in Table 1-2.

Table 1-2. Data references.

Subactivity	Database	Identity number
Inmätning av punkter längs de refraktionsseismiska profilerna LSM000504–LSM000508.	SICADA	Field note 486
Refraktionsseismiskda data från Laxemar hösten 2004. Profilerna LSM000504–LSM000508.	SICADA	Field note 539

2 Objective and scope

The main objective of the investigation was to investigate the soil depth in order to find the most suitable locations for digging trenches to expose the rock surface for geological mapping. Another objective was to investigate possible tectonic lineaments predicted by different geological and geophysical methods /1/, /2/.

Five profiles with a total length of 2,880 m were measured. The location of the profiles is shown in Figure 1-1.

3 Equipment

3.1 Description of equipment/interpretation tools

3.1.1 Recording instrument

The signals from the geophone cable are recorded digitally in SEG-2 format by a 24-channel instrument, ABEM Terraloc MK6, Figure 3-1.

Figure 3-1. *The recording instrument, ABEM Terraloc MK6.*

4 Execution

4.1 General

The refraction seismic measurements was performed according to the method description for refraction seismic SKB MD 242.001 (SKB internal controlling document).

4.1.1 Refraction seismic measurements

The energy source used was a normal commercial explosive. The charges are buried into the ground. The electrical detonators are ignited with a separate shot cable. The vibrations in the ground are picked up by geophones, in this project placed with 5 m spacing along the survey line. The signals from the geophones are carried to the recording instrument by a geophone cable. In this project two cables with a total of 24 outlets was used which means that a full spread covers 115 m in length.

4.1.2 Line survey

Before the seismic measurements the lines were staked and a line survey was performed and the coordinates for geophone points were measured for every 10:th of metre. The measurements were performed by a Total station and a GPS/RTK receiver. The resolution in X-, Y- and Z- coordinates is better than 0.1 m in X- and Y- coordinates and better than 0.3 m in Z- coordinates.

4.2 Analyses and interpretation

4.2.1 Data extraction

The shot records were visually inspected and subsequently printed on paper. The arrival times from the different shots were picked manually and plotted as time-distance graphs on paper.

4.2.2 Interpretation

The interpretation was carried out manually with conventional methods. These methods are well described by Sjögren /4/.

4.3 Nonconformities

There are no major non-conformities as compared to the activity plan.

5 Results

The results discussed in the following section are shown as seismic sections in Figures A-1 to A-5 in Appendix 1. The seismic sections are delivered in .dwg format in the length scale 1:1,000 and depth scale 1:200. In Appendix 1 the scale has been reduced according to the layout of the page in the Appendix. The location of the measured lines is shown in Figure 1-1.

5.1 Interpreted results

In the profiles in Appendix 1 velocities in the uppermost part corresponds to the overburden. Velocities from 300 up to 700 m/s correspond to loose topsoil. Velocities from 800 up to 2,200 m/s correspond to moraine above or below ground water table.

Profile 504 (LSM000504), shown in Figure A-1 in Appendix 1, starts on outcropping rock in the south and ends close to the power lines towards the north. The topography is fairly flat. The soil layer is mostly 4–6 m. The velocities below the loose topsoil are mostly in the range 1,400–1,700 m/s indicating a sandy moraine. Two minor zones with sound velocities of 3,500 and 4,000 m/s respectively were found during the interpretation. Apart from these zones, the bedrock quality seems to be good or very good with a velocity of 5,200 up to 5,500 m/s.

Profile 505 (LSM000505), shown in Figure A-2 in Appendix 1, starts on outcropping bedrock and crosses then a valley with flat ground. After chaining 140 m the terrain is the one typical for moraine, with small hills and uneven surface. The soil depth across the valley is 4–5 m and the sound velocity indicates a silty/sandy soil material. Between chaining 150 m and 250 m the soil depth is 7–9 m and sound velocities in the range of 1,700–2,200 m/s which indicates a more typical moraine. The sound velocity in the bedrock is normally around 5,500 m/s indicating a good bedrock quality. Three minor zones with sound velocities around 4,000 m/s were found during the interpretation.

The profile 506 (LSM000506), shown in Figure A-3 in Appendix 1, connects to the end of LSM000277 (277) and the beginning of LSM000280 (280). The two profiles 277 and 280 were investigated during May 2004 /5/. The topography is varied with small hills and small depressions in between. The soil depth is generally 3–5 m. In the vicinity of chaining 250 m the depth is around 7 m. Three narrow low velocity zones, 5 m wide, in the bedrock are found. The velocities of these zones are between 3,500 and 4,000 m/s. The existence of the zone at chaining 360 m is uncertain. The bedrock seem otherwise to be of good quality with a velocity of 5,000 up to 5,600 m/s.

The profile 507 (LSM000507), is shown in Figure A-4 in Appendix 1. Outcropping bedrock is found at the beginning and at the end of the profile. In between there is mostly moraine. The thickest soil is 6–9 m under the small hill between chaining 190 m and 320 m. The sound velocity in the bedrock varies between 5,300 m/s and 5,900 m/s. Only two narrow zones with a lower than normal sound velocity is found. The velocities are around 4,000 m/s.

Profile P508 (LSM000508), shown in Figure A-5 in Appendix 1, starts on outcropping bedrock. From the beginning up to chaining 100 m and from chaining 470 m up to the end of the profile the soil layer is thin or absent. Along the rest of the profile the soil thickness mostly is in the range 3–6 m. The sound velocity in the bedrock is between 5,300 m/s and 5,500 m/s indicating a good quality bedrock. Four thin zones with estimated sound velocity in the range 3,700–4,000 m/s are found. The one at chaining 530 m is marked as uncertain.

5.2 Location of low velocity zones

The location of low velocity zones is shown in Figure 5-1.

In this survey the sound velocities in the bedrock is generally 5,300 m/s or higher. This indicates solid bedrock. A number of usually 5 m wide zones with lower sound velocity are found. The sound velocity for most of these zones is around 4,000 m/s. When calculating the sound velocity for the bedrock the lower limit of the breadth of a low velocity zone is given by the distance between the geophones, in this case 5 m. This means that a zone with fractures that show up during the interpretation, if it exists, can be much thinner than 5 m.

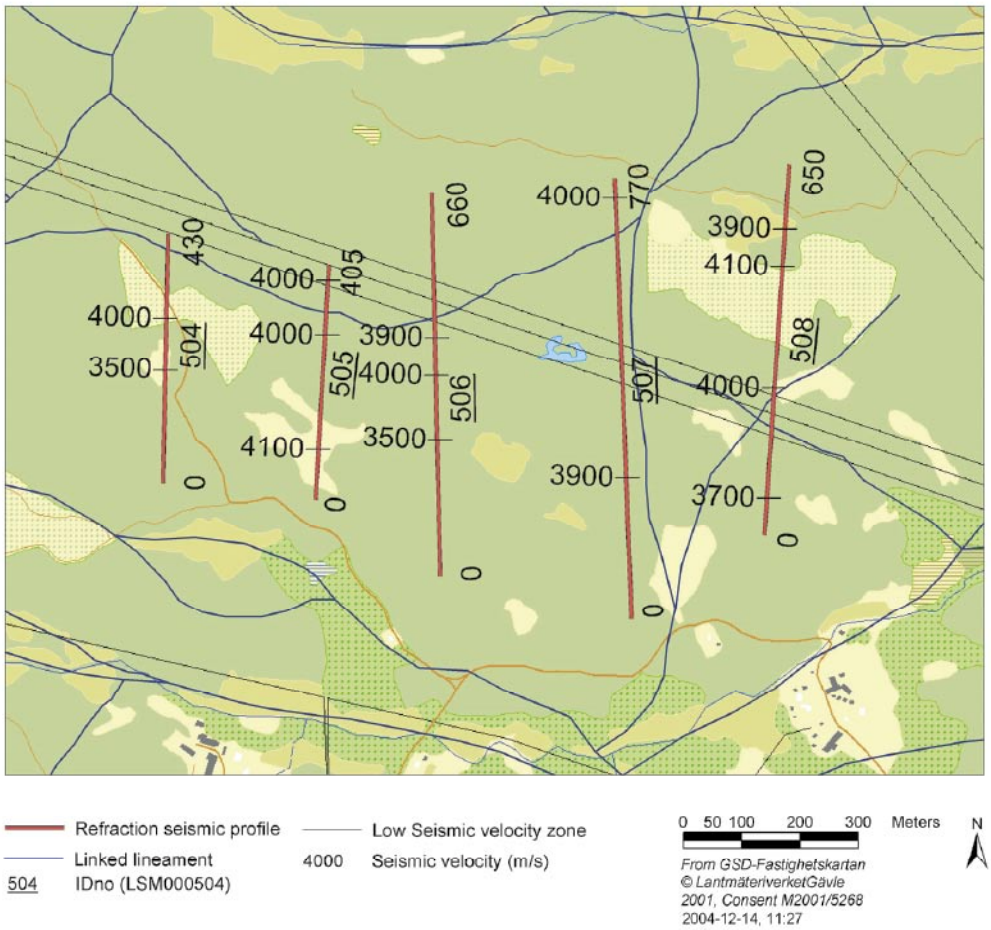

Figure 5-1. *Location of low velocity zones in the bedrock interpreted from this refraction seismic survey. The low velocity zones are marked with tic-lines along the profiles. Lineaments presented are linked lineaments interpreted from air photos and helicopter airborne geophysics /3/.*

5.3 Data delivery

Raw data from the measurements were delivered directly after the termination of the field activities.

The delivered data have been inserted in the database (SICADA) of SKB. The SICADA reference to the present activity is field note no 539. The SICADA referernce to the line survey data is field note no 486.

Data delivered directly after termination of the field activities were:

- Field log for record numbers and shot and geophone geometry.
- Seismic raw data recordings in SEG-2 format.

Together with this report the following data are delivered:

- Ritningar_Laxemar_II.dwg
- EG170_Line surveying_Laxemar_Redovisning_2004-10-22.xls (listing of line coordinates)
- GP320_Refraction seismics_Laxemar_2.xls

References

/1/ **Triumf C A, 2003.** Oskarshamn site investigation. Identification of lineaments in the Simpevarp area by the interpretation of topographical data. SKB P-03-99. Svensk Kärnbränslehantering AB.

/2/ **Triumf C A, Thunehed H, Kero L, Persson L, 2003.** Oskarshamn site investigation. Interpretation of airborne geophysical survey data. Helicopter borne survey data of gamma ray spectrometry, magnetics and EM from 2002 and fixed wing airborne survey data of the VLF-field from 1986. SKB P-03-100. Svensk Kärnbränslehantering AB.

/3/ **Triumf C A, 2004.** Oskarshamn site investigation. Joint interpretation of lineaments. SKB P-04-49. Svensk Kärnbränslehantering AB.

/4/ **Sjögren B, 1984.** Shallow refraction seismics. ISBN 0-412-24210-9.

/5/ **Lindqvist G, 2004.** Oskarshamn site investigation. Refraction seismic measurements in Laxemar. SKB P-03-134. Svensk Kärnbränslehantering AB.

Appendix 1

Interpretation of refraction seismic sections in Laxemar

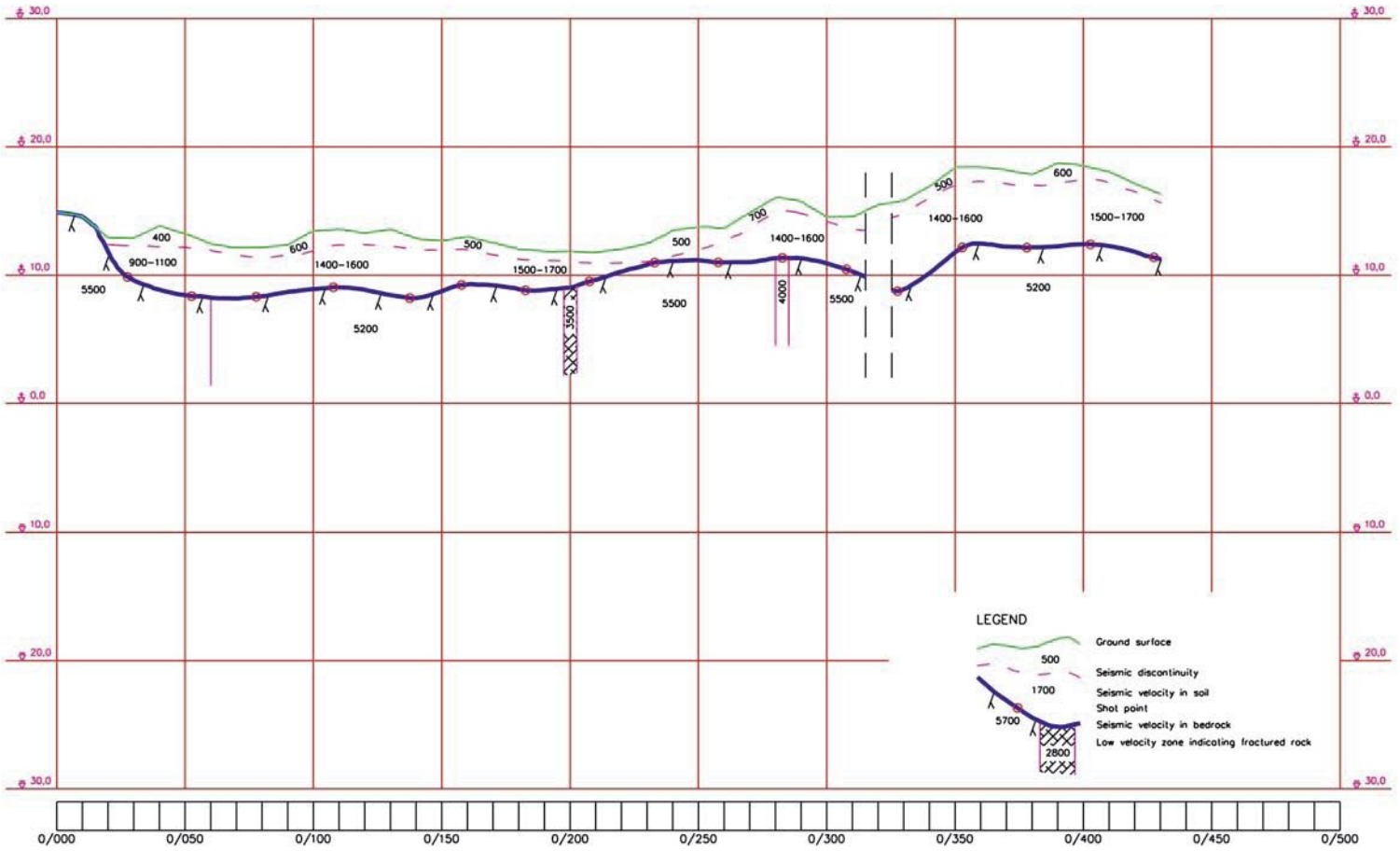

Figure A-1. *Results from interpretation of refraction seismics in Laxemar. Line LSM000504.*

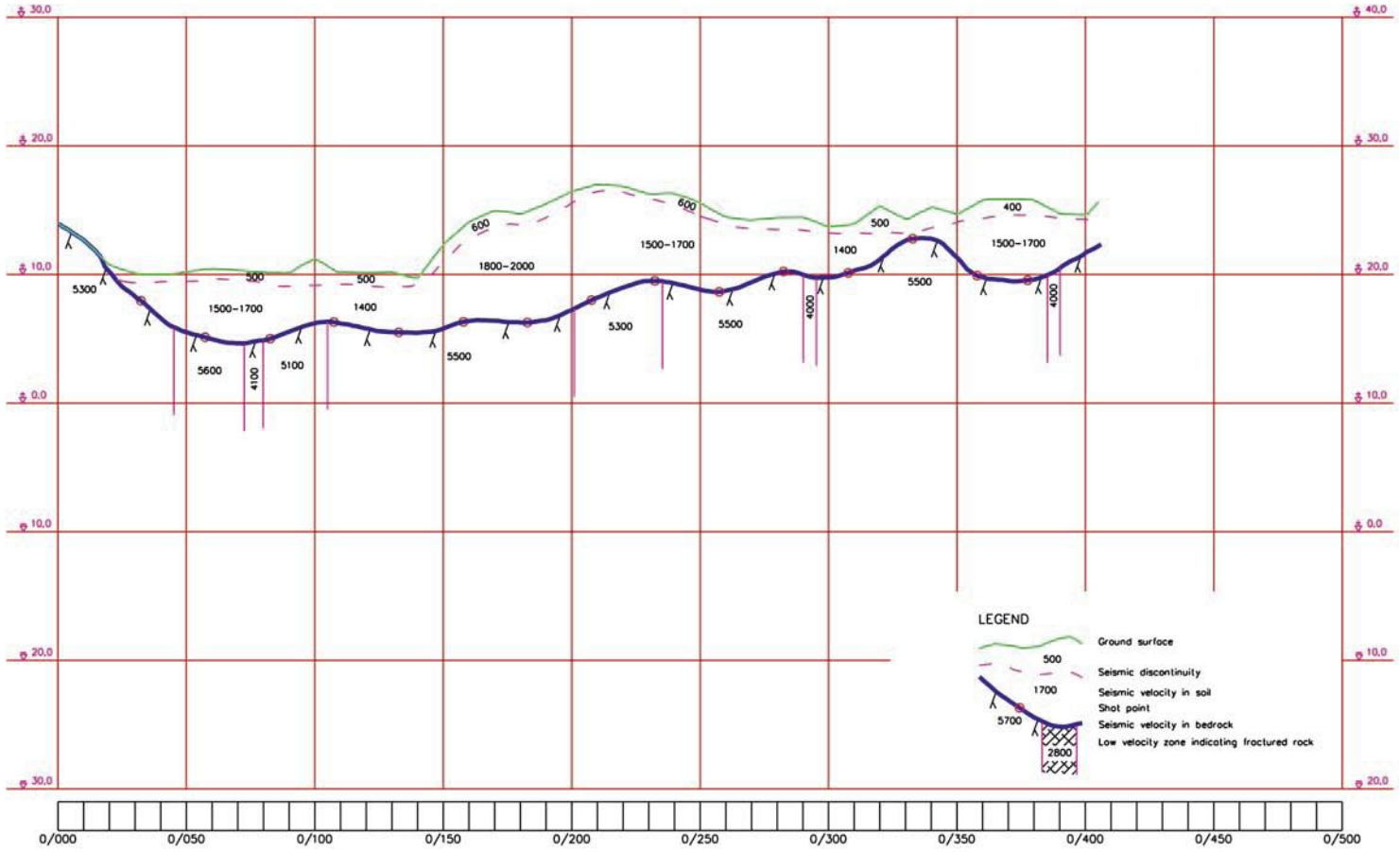

Figure A-2. *Results from interpretation of refraction seismics in Laxemar. Line LSM000505.*

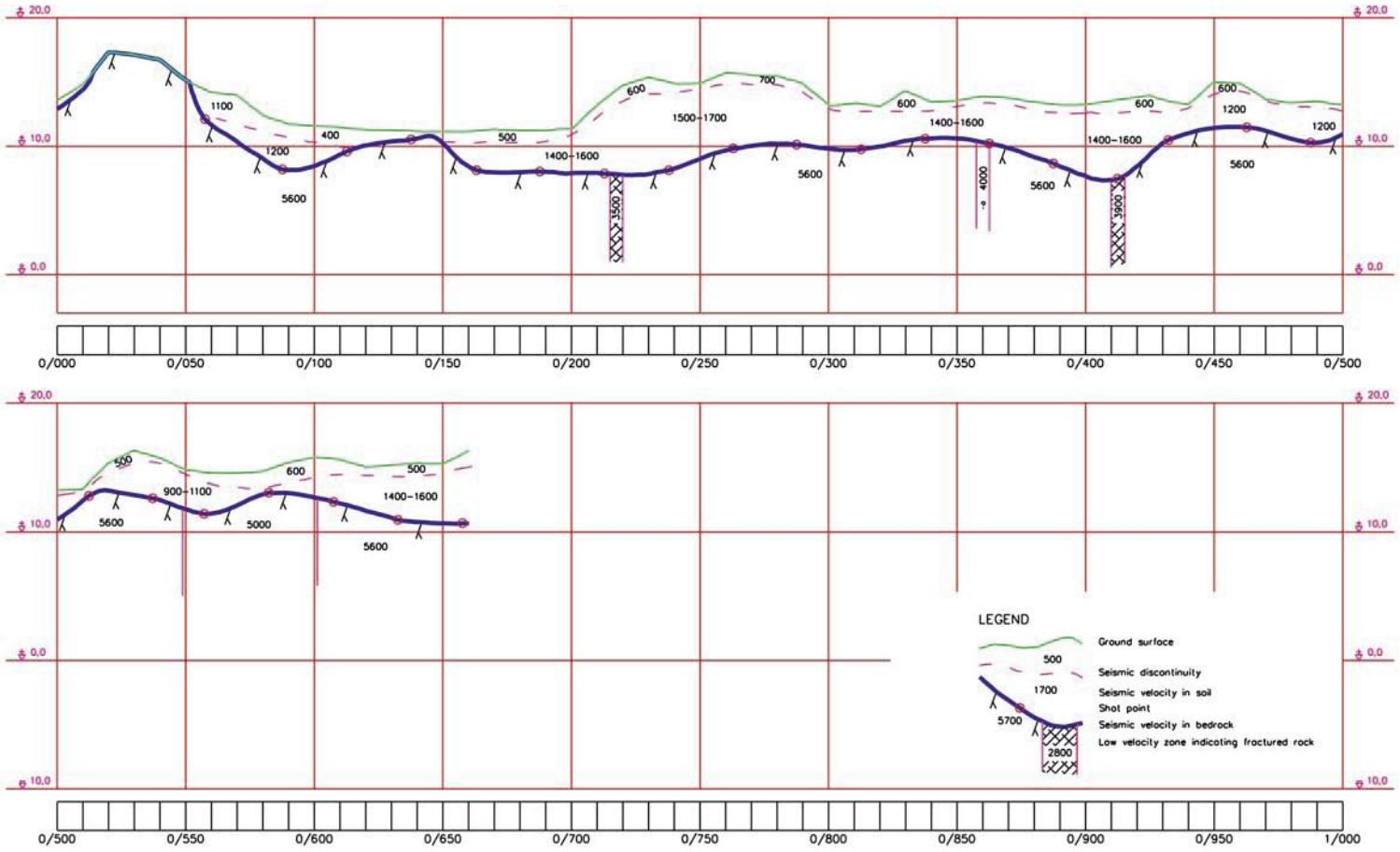

Figure A-3. *Results from interpretation of refraction seismics in Laxemar. Line LSM000506.*

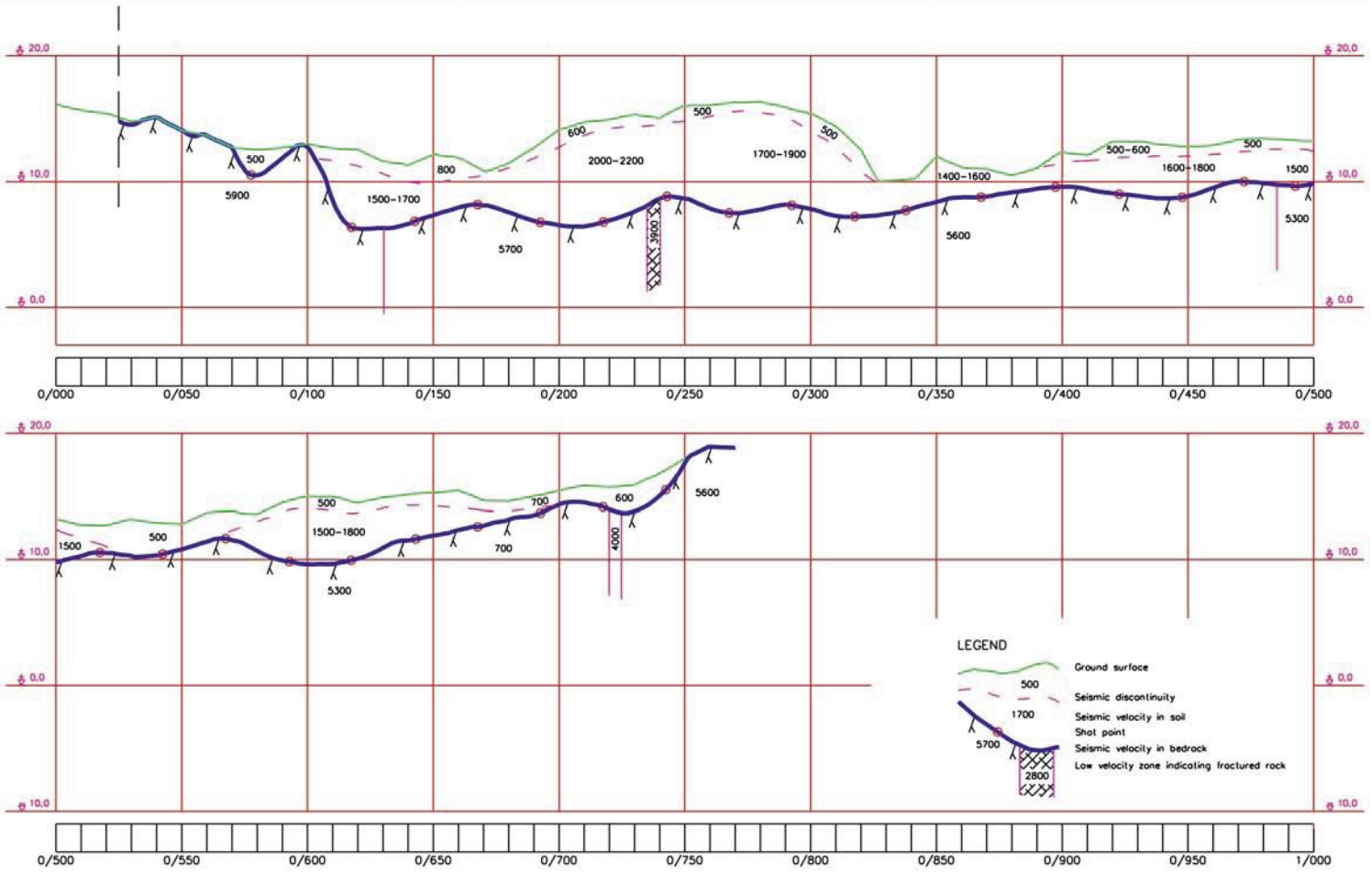

Figure A-4. *Results from interpretation of refraction seismics in Laxemar. Line LSM000507.*

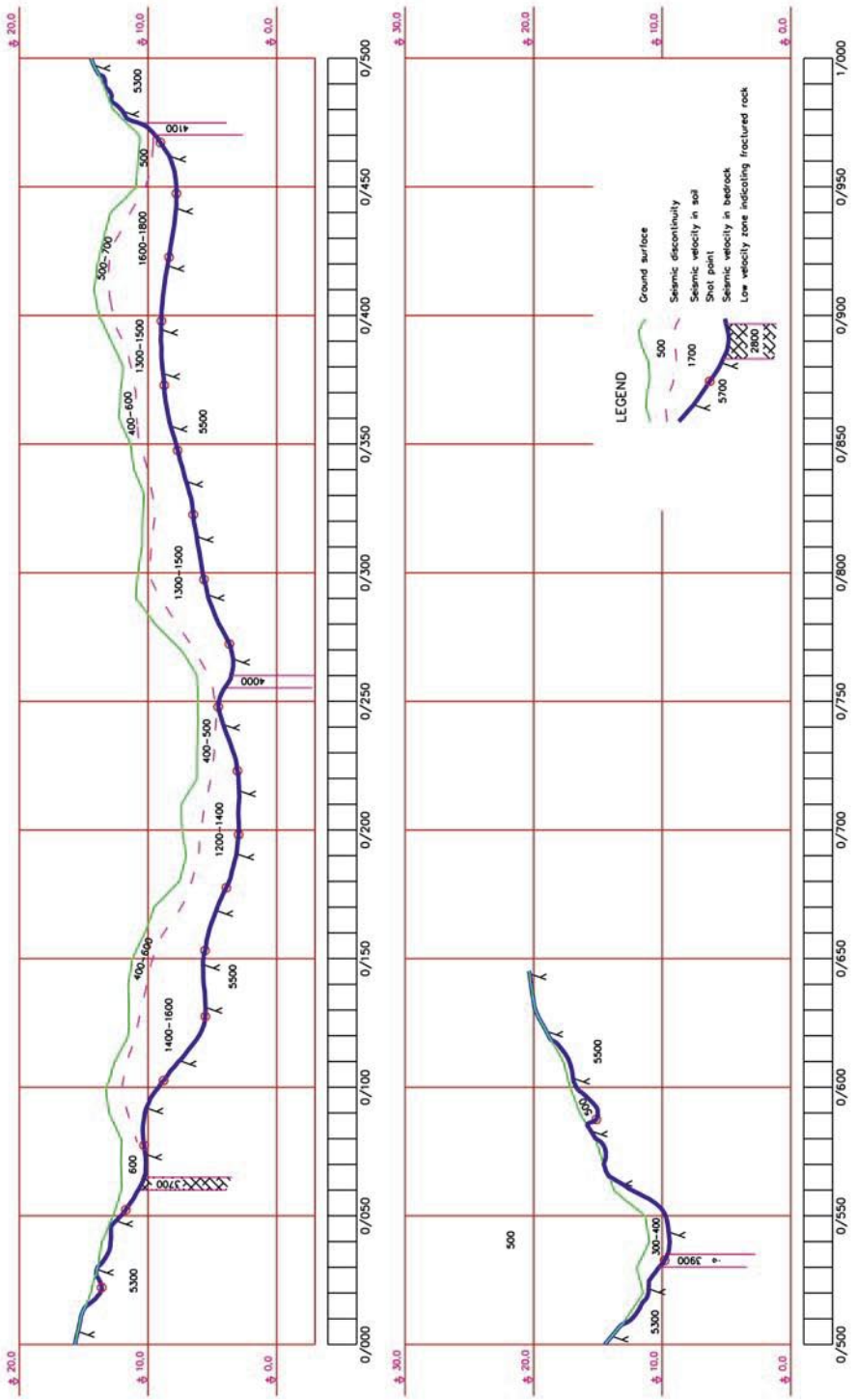

Figure A-5. *Results from interpretation of refraction seismics in Laxemar. Line LSM000508.*