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Oskarshamn site investigation

Refraction seismic measurements in Laxemar

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Abstract

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

The objective of the refraction seismic survey was to contribute to the determination of whether the interpreted lineaments are deformation zones or not. The contribution is made by means of interpretation of seismic velocities in the shallow rock and in the overburden. Geometrical information such as thickness of overburden along the profiles is also obtained.

Eight profiles with a total length of 3,890 m were measured. The survey lines were placed to cross over lineaments mainly interpreted from air photos or geophysical measurements from helicopter. Most of the interpreted lineaments were confirmed as a zone with lower seismic velocity, 2,500 m/s up to 4,000 m/s, while the velocity of the sound rock were in the range from 5,000 m/s up to 5,800 m/s with a mean value of 5,416 m/s.

Sammanfattning

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

Syftet med undersökningarna var att undersöka om möjliga tektoniska lineament identifierade med olika geologiska och geofysiska metoder orsakas av deformationszoner i berggrunden eller inte. Undersökningen genomförs genom att tolka seismiska gånghastigheter i den övre berggrunden och ovanliggande jordtäcke. Geometrisk information som tjockleken på överliggande jordtäcke längs med profilerna erhålls dessutom.

Åtta profiler med en total längd av 3 890 meter undersöktes. Undersökningslinjerna placerades för att korsa tolkade lineament identifierade från flygfotografier och från geofysiska mätningar med helikopter. Huvuddelen av de tolkade lineamenten veriferades som en zon med lägre utbredningshastighet i berget, från 2 500 m/s upp till 4 000 m/s, medan utbredningshastigheten i friskt berg varierade mellan 5 000 m/s upp till 5 800 m/s med ett medelvärde på 5 416 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 400-04-038 (SKB internal controlling document). In Table 1-1 the controlling documents for performing this activity are listed.

Table 1-1. Controlling documents for the performance of the activity (SKB internal controlling documents).

Activity plan	Number	Version
Refraktionsseismik i Laxemar	AP PS 400-04-038	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för refraktionsseimik	SKB MD 242.001	1.0

Eight profiles with a total length of 3,890 m were measured. The survey lines were placed to cross over lineaments mainly interpreted from air photos or geophysical measurements from helicopter /1, 2, 3/.

The location of the survey lines is shown in Figure 1-1.

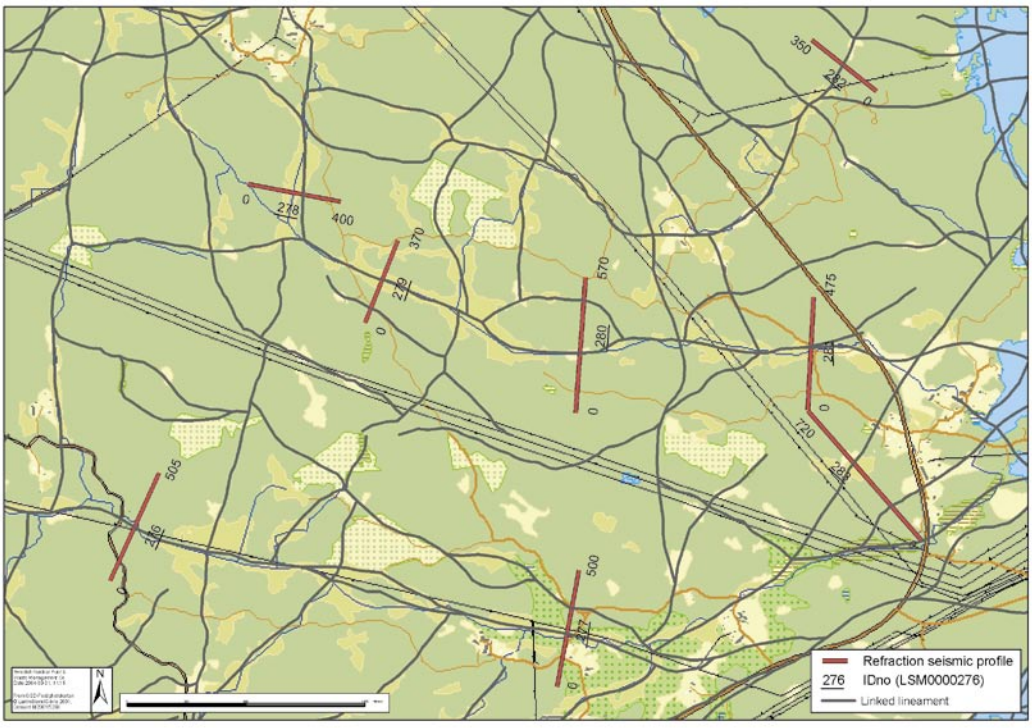

Figure 1-1. *Location of refraction seismic profiles in Laxemar subarea. Lineaments presented are linked lineaments interpreted from air photos and helicopter airborne geophysics /3/.*

2 Objective and scope

The objective of the refraction seismic survey was to contribute to the determination of whether the interpreted lineaments /1, 2, 3/ are deformation zones or not. The contribution is made by means of interpretation of seismic velocities in the shallow rock and in the overburden. Geometrical information such as thickness of overburden along the profiles is also obtained. 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 10th of m and for line LSM000283 the geophone points were measured every 5th of m. 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-coordinate.

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 5-1 to 5-8 in Appendix 1. The seismic sections were 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 to 8 velocities in the uppermost part corresponds to the overburden. Velocities from c 300 up to 700 m/s correspond to loose top soil. Velocities from 800 up to 1,800 m/s correspond to moraine above or below ground water table.

Profile 276 (LSM000276), shown in Figure 5-1 in Appendix 1, has a rather rough topography. Along the first 170 m and between chaining 280 m and 310 m there are large boulders at the surface. It seems likely that a major part of the soil layer along these sections consists of large boulders with varying mixture of finer soil material. In the topographic lowest valley a low velocity zone, c 3,000 m/s, in the bedrock is found. A low velocity zone of 3,900 m/s is found at chaining 40 m. Besides, the bedrock quality seems to be good or very good with a velocity of 5,300 up to 5,700 m/s.

Profile 277 (LSM000277), shown in Figure 5-2 in Appendix 1, show generally small soil depth. The exception is a depression in the bedrock elevation between chaining 130 m and 270 m. The bedrock seems to be of good quality also across the above-mentioned section with a velocity of 5,300 up to 5,800 m/s. The only exception is a narrow low velocity zone centred at chaining 192 m with a velocity of 3,700 m/s.

Profile 278 (LSM000278), shown in Figure 5-3 in Appendix 1, is measured from west towards east. In the central part the survey line crosses a valley. The soil layer is as thickest around 8 m. Three narrow low velocity zones, between 5–10 m thick, in the bedrock are found under the valley. The velocities of these zones are between 3,500 and 3,900 m/s. The bedrock seem otherwise to be of good quality with a velocity of 5,300 up to 5,600 m/s.

Profile 279 (LSM000279), shown in Figure 5-4 in Appendix 1, crosses two valleys. The soil thickness is as most around 9 m at chaining 187 m. At the same location a 10 m wide low velocity zone in the bedrock with sound velocity of 2,800 m/s is found. Two narrower zones are also found at chaining 98 m and 323 m with a velocity of 4,000 m/s and 3,600 m/s respectively. The bedrock seem otherwise to be of good quality with a velocity of 5,200 up to 5,700 m/s.

Profile 280 (LSM000280), shown in Figure 5-5 in Appendix 1, starts with its first 100 m in a forest area cleared of trees. The soil depth in this part is around 6 m. A similar depression in the bedrock topography is found below the valley with cultivated land between chaining 210 m and 280 m. Two low velocity zones in the bedrock is found in connection with the second bedrock depression. One c 10 metre wide zone with a velocity of 3,200 m/s is located towards the northern side of the valley. The other low velocity zone has a velocity of 3,800 m/s. A minor low velocity zone is also found at chaining 362 m with a velocity of 3,800 m/s. The bedrock seem otherwise to be of good quality with a velocity of 5,000 up to 5,700 m/s.

Profile 281 (LSM000281), shown in Figure 5-6 in Appendix 1, starts close to the end of profile 283 (LSM000283). Between chaining 220 m and 280 m there is a valley with some cultivated land. The soil depth is as maximum around 15 m at chaining 265 m. At the same location a 7.5 m wide low velocity zone in the bedrock with a velocity of 2,500 m/s is found. Another low velocity zone is located around chaining 425 m. The velocity of this zone is 3,900 m/s. The bedrock seem otherwise to be of good quality with a velocity of 5,300 m/s.

Profile 282 (LSM000282), shown in Figure 5-7 in Appendix 1, is located in the northeastern part of the investigation area. The profile is measured from southeast towards northwest. It runs mostly on rock or very thin soil layer. The soil thickness is as most around 3 m in the valleys at chaining 180 m and close to the end of the profile at chaining 310 m. One minor low velocity zone in the bedrock with a velocity of 3,800 m/s is found at chaining 168 m. The bedrock seem otherwise to be of good quality with a velocity of 5,000 up to 5,700 m/s.

Profile 283 (LSM000283), shown in Figure 5-8 in Appendix 1, has a length of 720 m. It is measured from southeast towards northwest. The bedrock is covered by soil with the exception between chaining 135 m and 160 m. The soil cover is however only 6 m or less. Only one narrow low velocity zone in the bedrock with a velocity of 3,300 m/s is found. It is located at chaining 292 m, which according to field notes is close to outcropping rock. The bedrock seem otherwise to be of good quality with a velocity of 5,000 up to 5,500 m/s.

5.2 Location of low velocity zones

The location of low velocity zones is shown in Figure 5-9. Most of the interpreted lineaments were confirmed as a zone with lower seismic velocity, 2,500 m/s up to 4,000 m/s, while the velocity of the sound rock were in the range from 5,000 m/s up to 5,800 m/s with a mean value of 5,416 m/s.

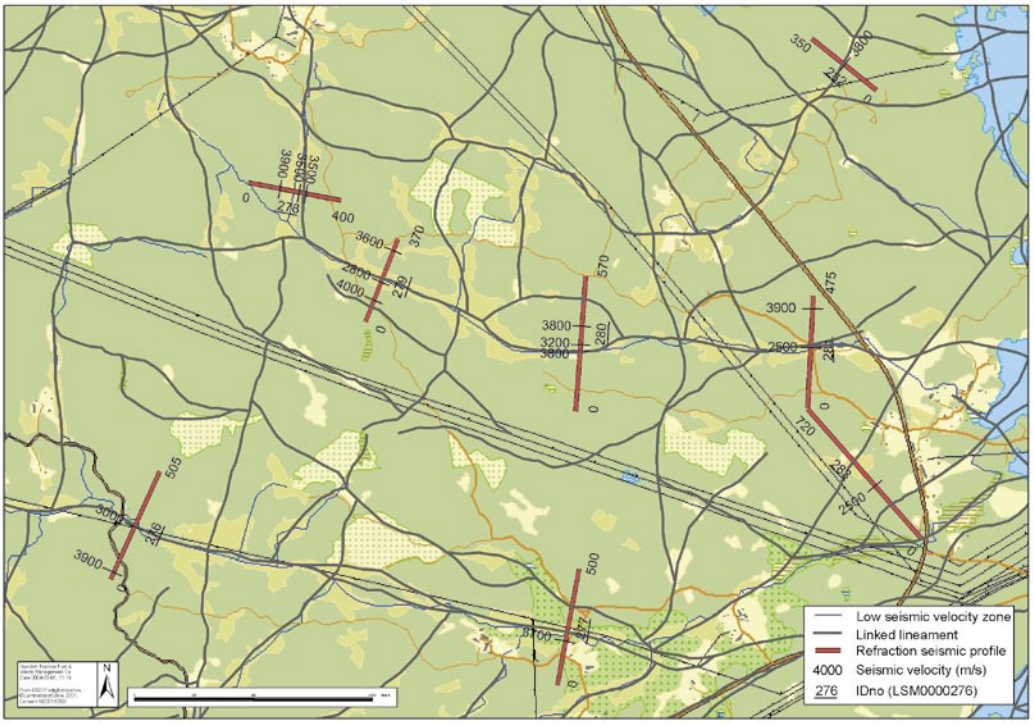

Figure 5-9. *Location of low velocity zones in the bedrock interpreted from this refraction seismic survey. The low velocity zones are marked with tic-lines along the profiles. Lineaments presented are linked lineaments interpreted from air photos and helicopter airborne geophysics /3/.*

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 371. The SICADA reference to the line survey data is field note no 365.

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:

- Laxemar_refr_seism.dwg
- EG170 - Line surveying_Laxemar_refraktion.xls (listing of line coordinates)
- GP320_Refraction seismics_Laxemar.xls (results from interpretation)

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.

Appendix 1

Interpretation of refraction seismic sections in Laxemar

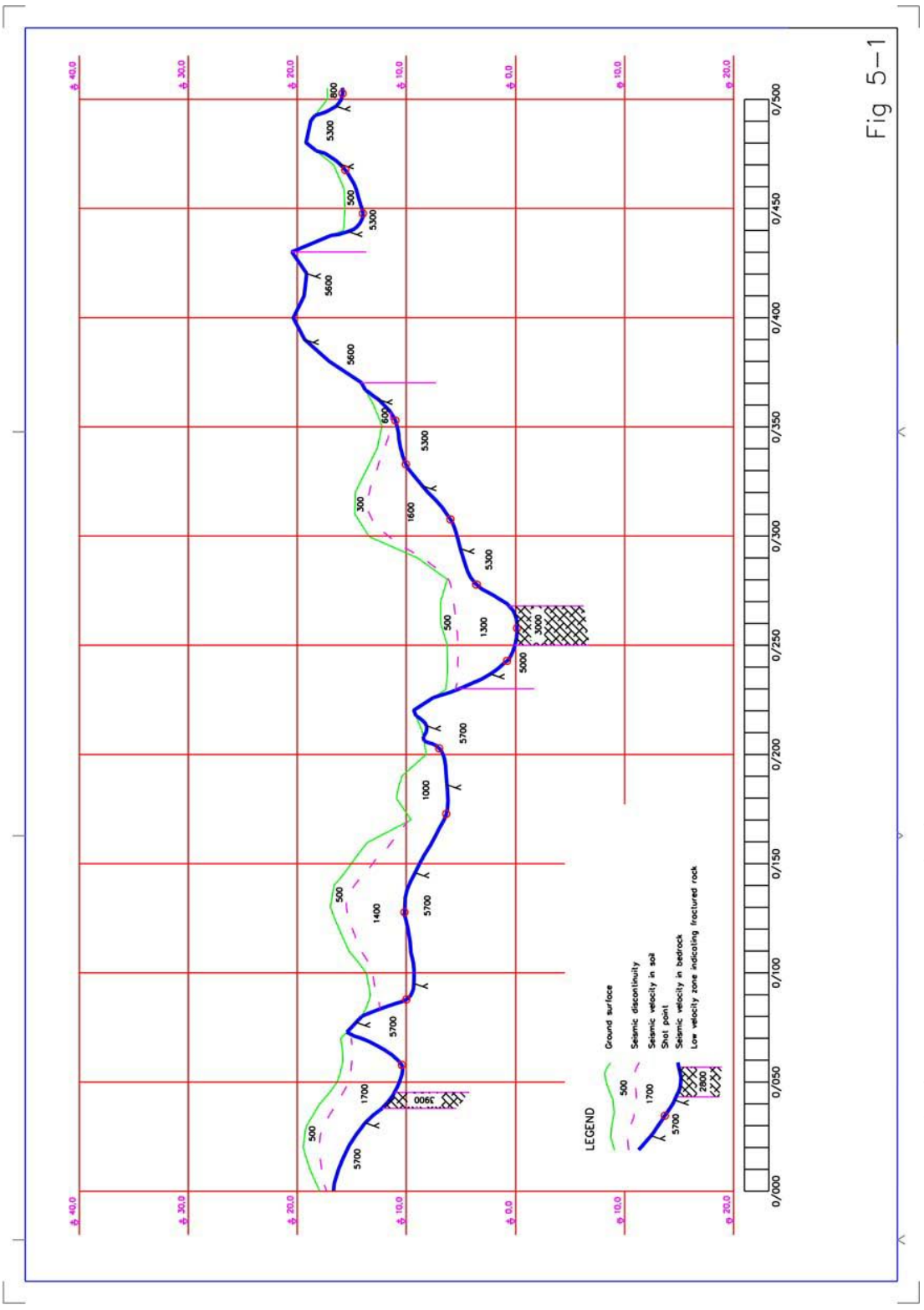

Figure 5-1. *Results from interpretation of refraction seismics in Laxemar. Line LSM000276.*

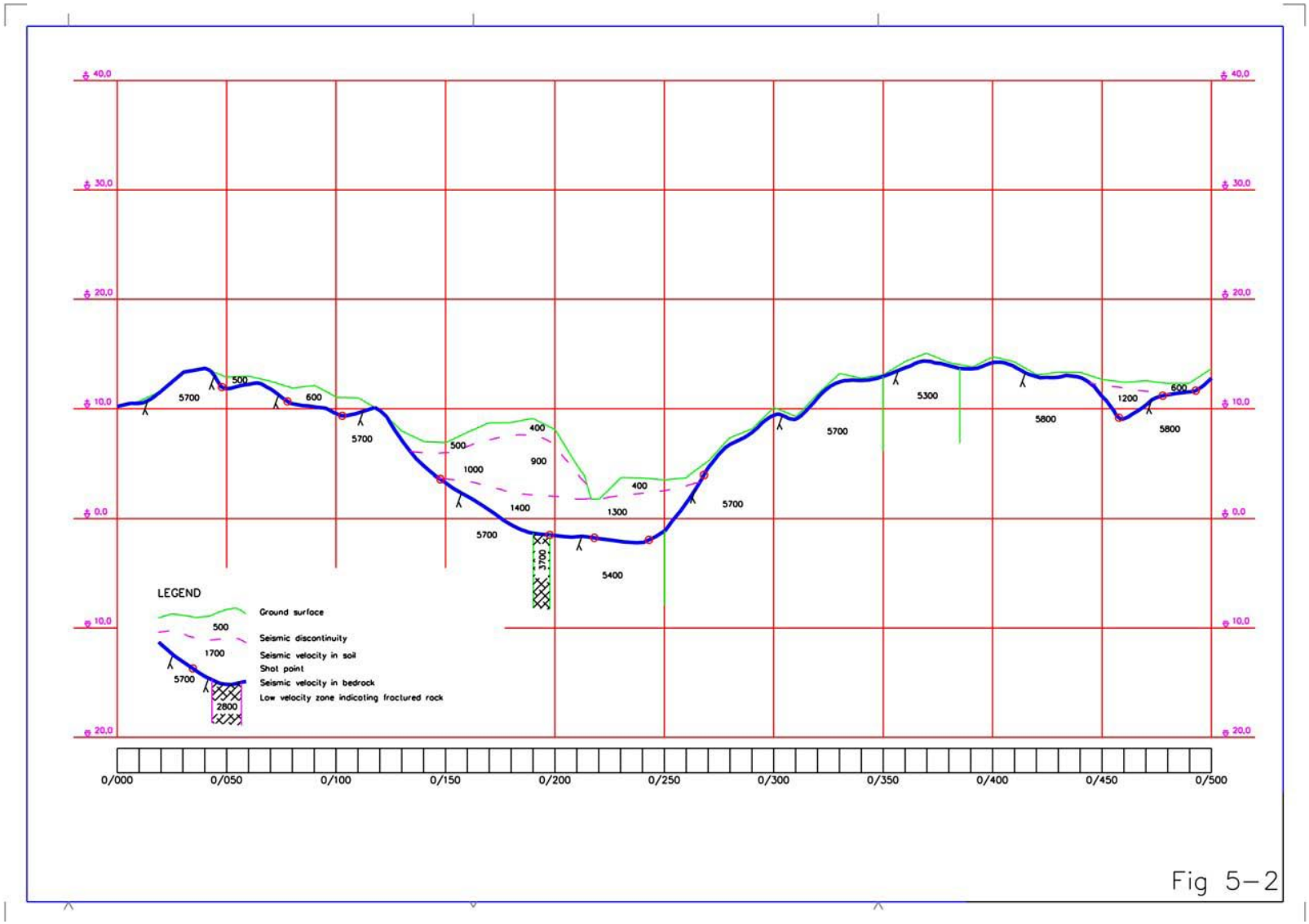

Figure 5-2. *Results from interpretation of refraction seismics in Laxemar. Line LSM000277.*

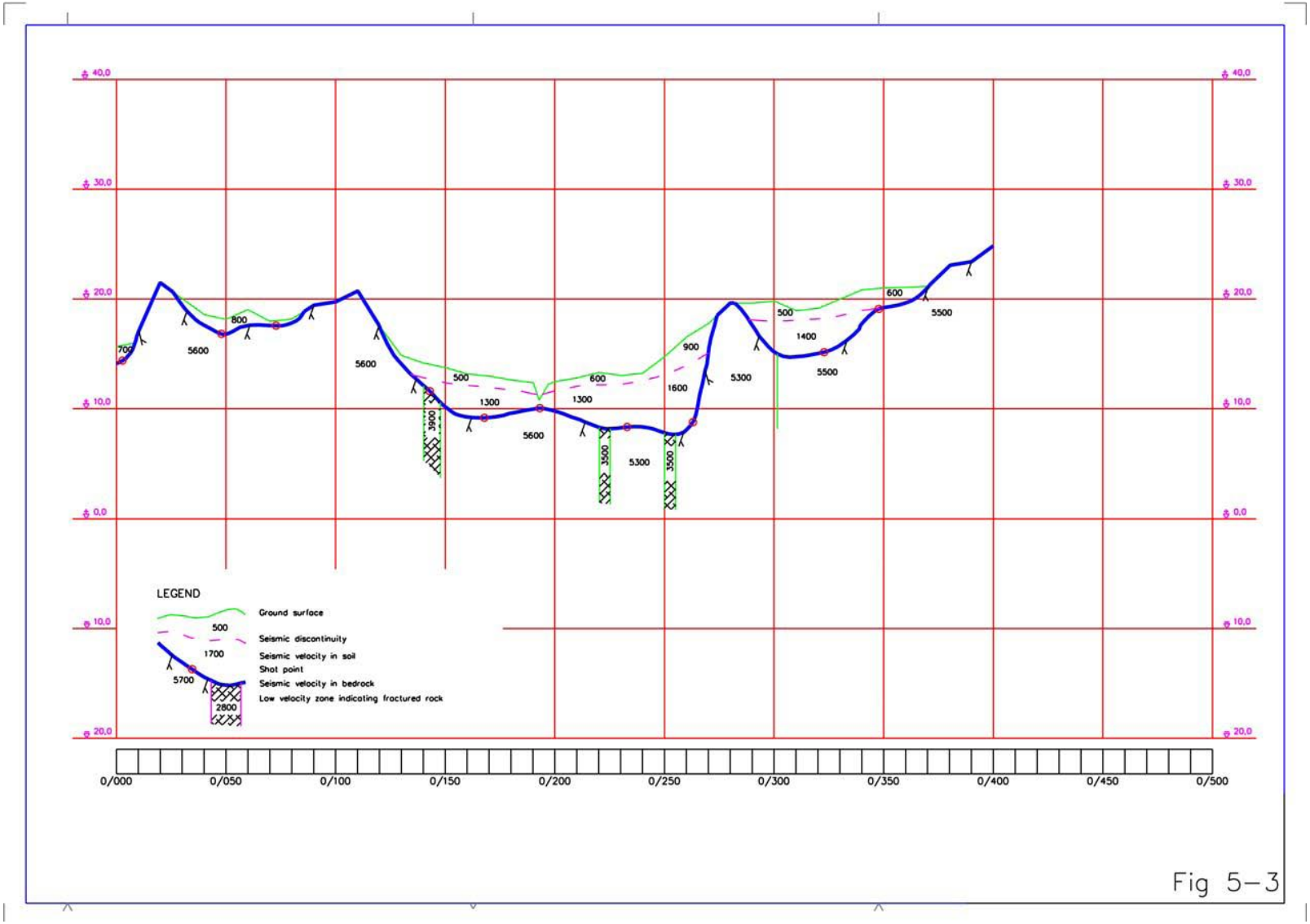

Figure 5-3. *Results from interpretation of refraction seismics in Laxemar. Line LSM000278.*

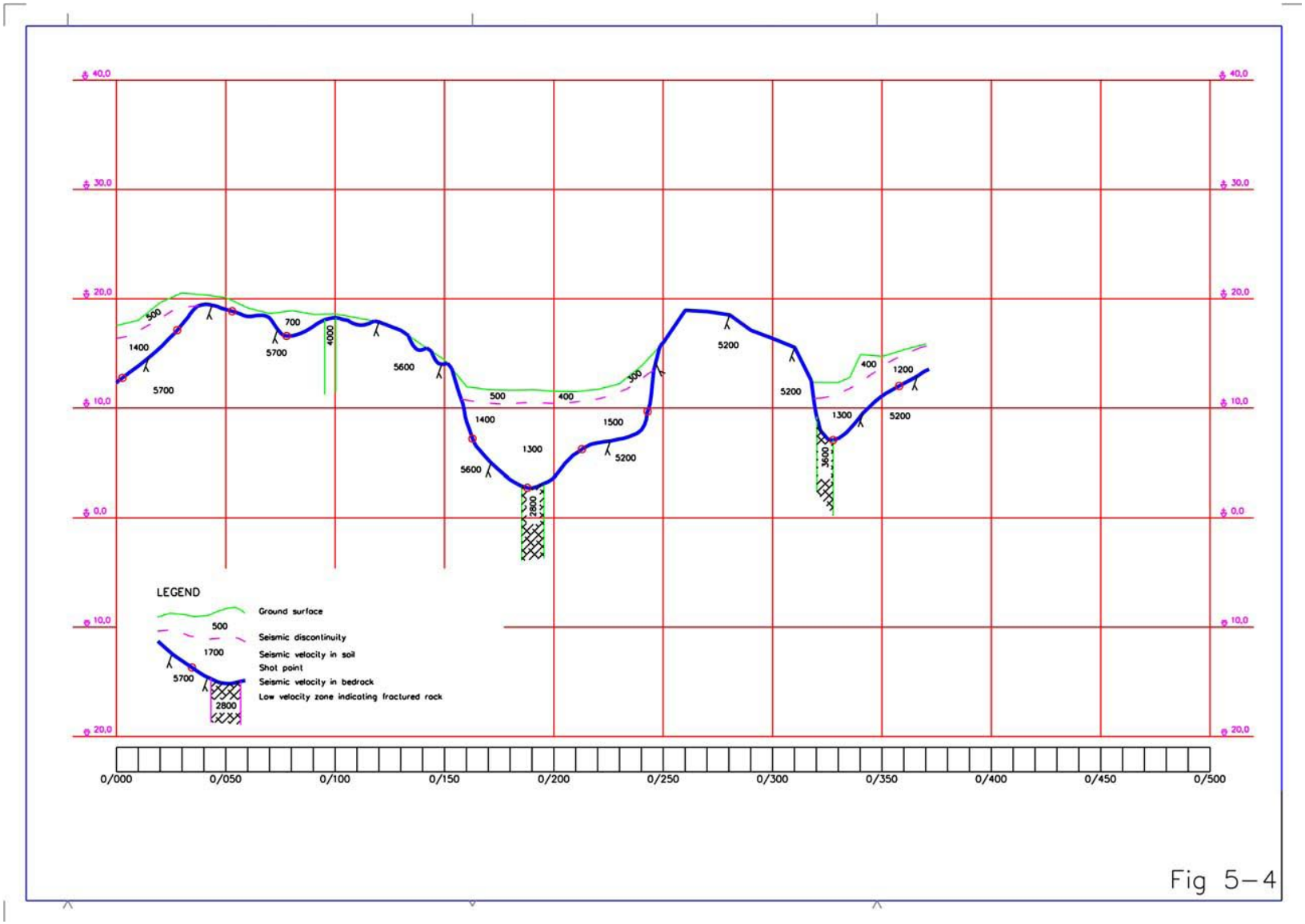

Figure 5-4. *Results from interpretation of refraction seismics in Laxemar. Line LSM000279.*

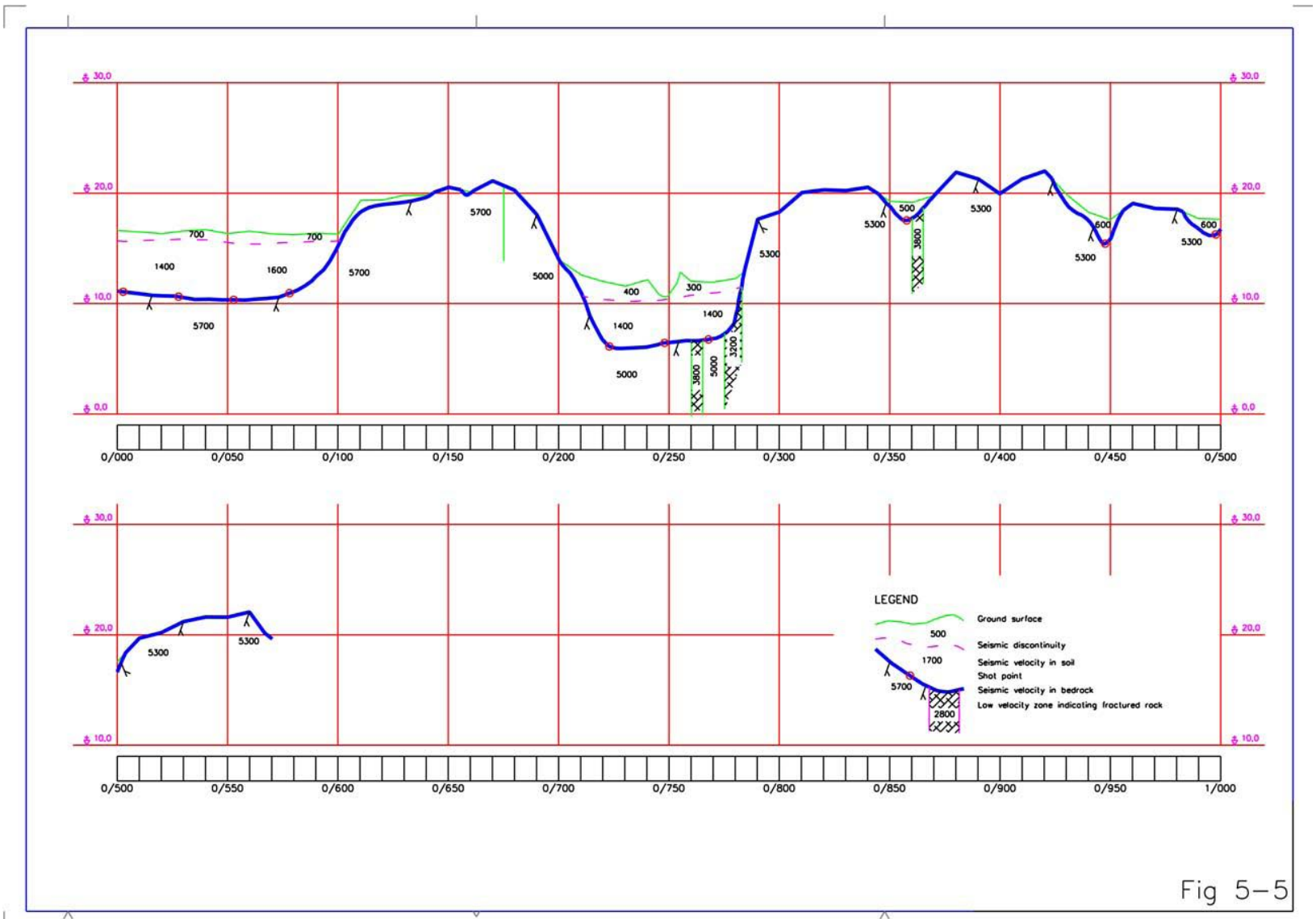

Figure 5-5. *Results from interpretation of refraction seismics in Laxemar. Line LSM000280.*

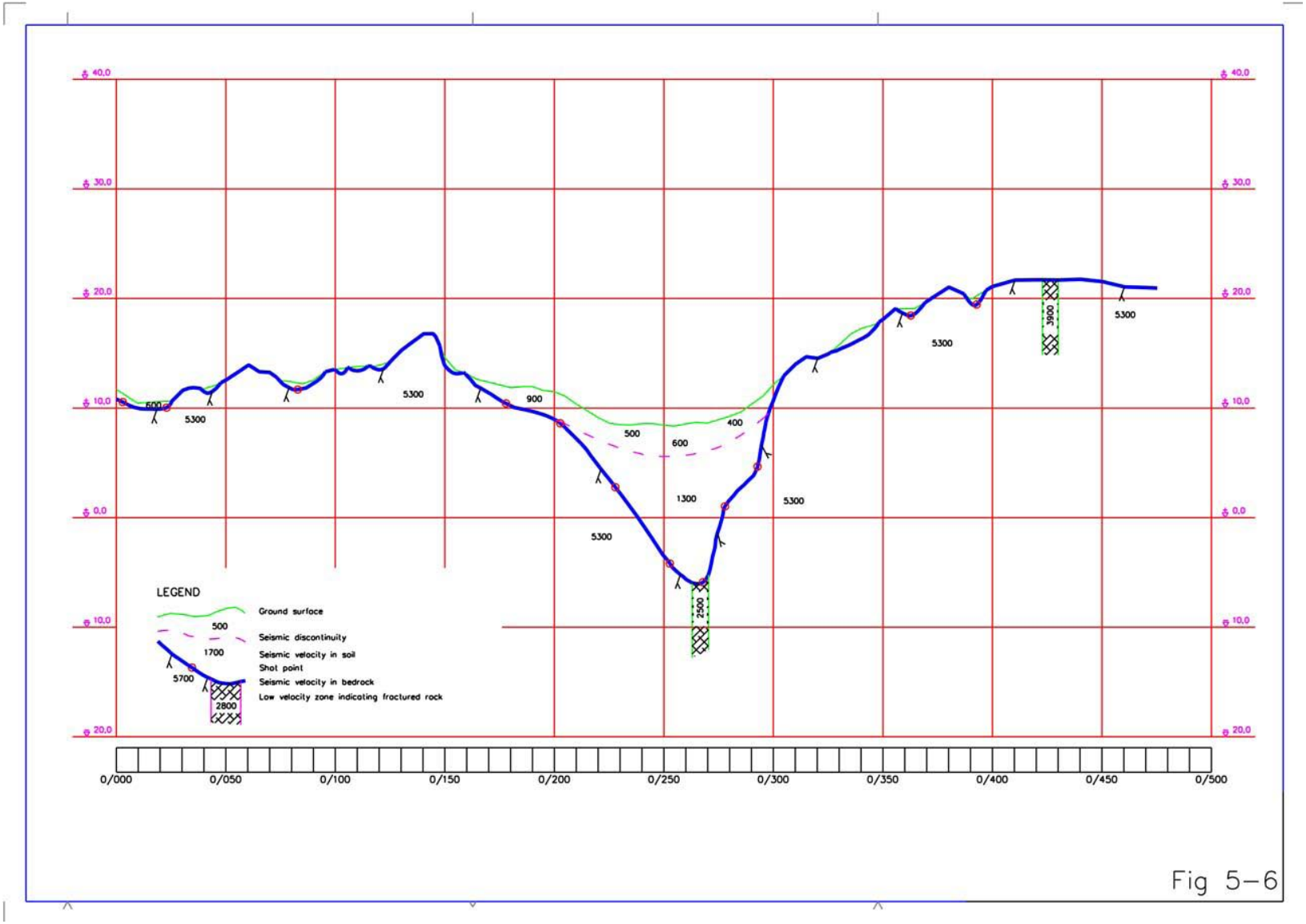

Figure 5-6. *Results from interpretation of refraction seismics in Laxemar. Line LSM000281.*

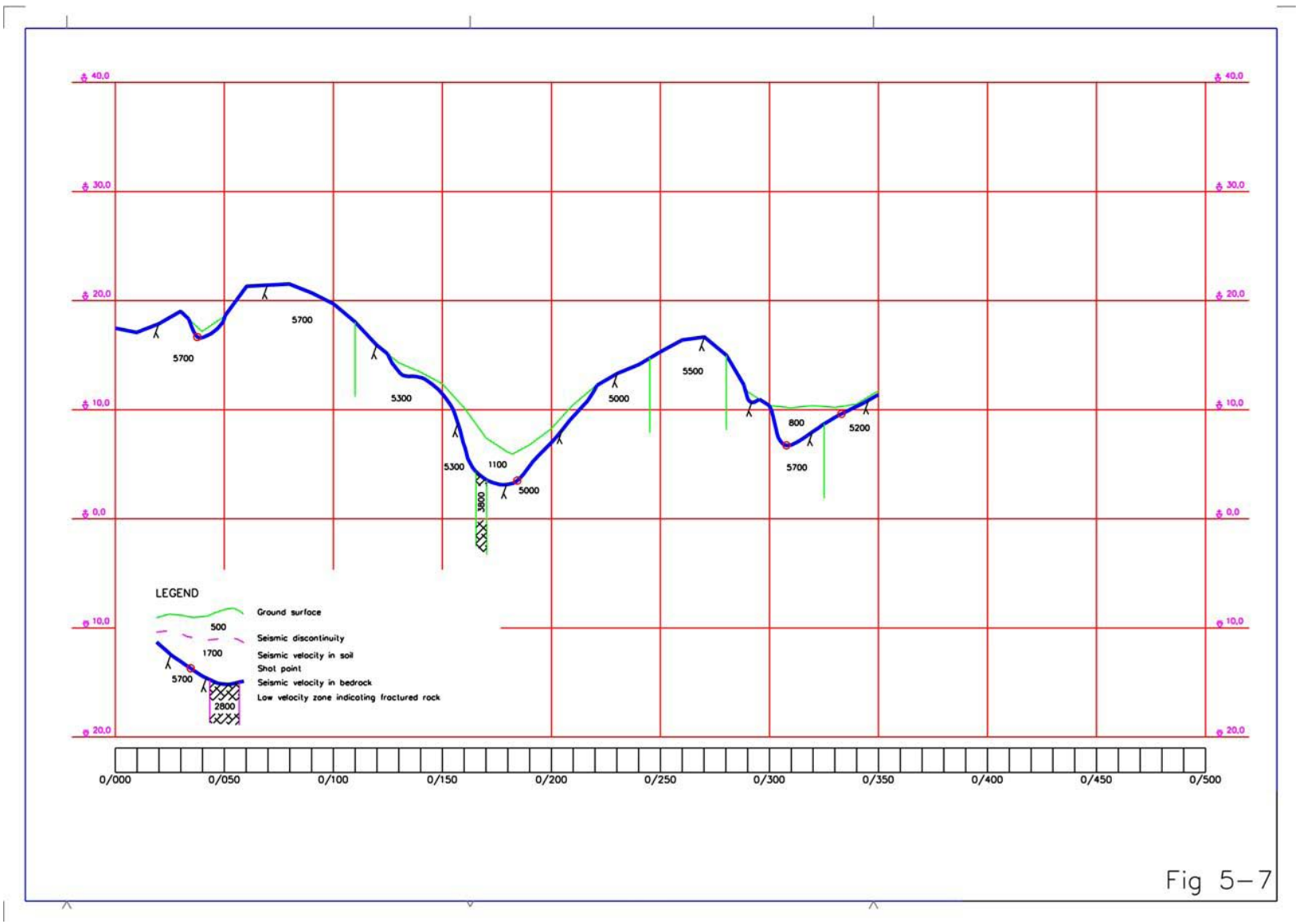

Figure 5-7. *Results from interpretation of refraction seismics in Laxemar. Line LSM000282.*

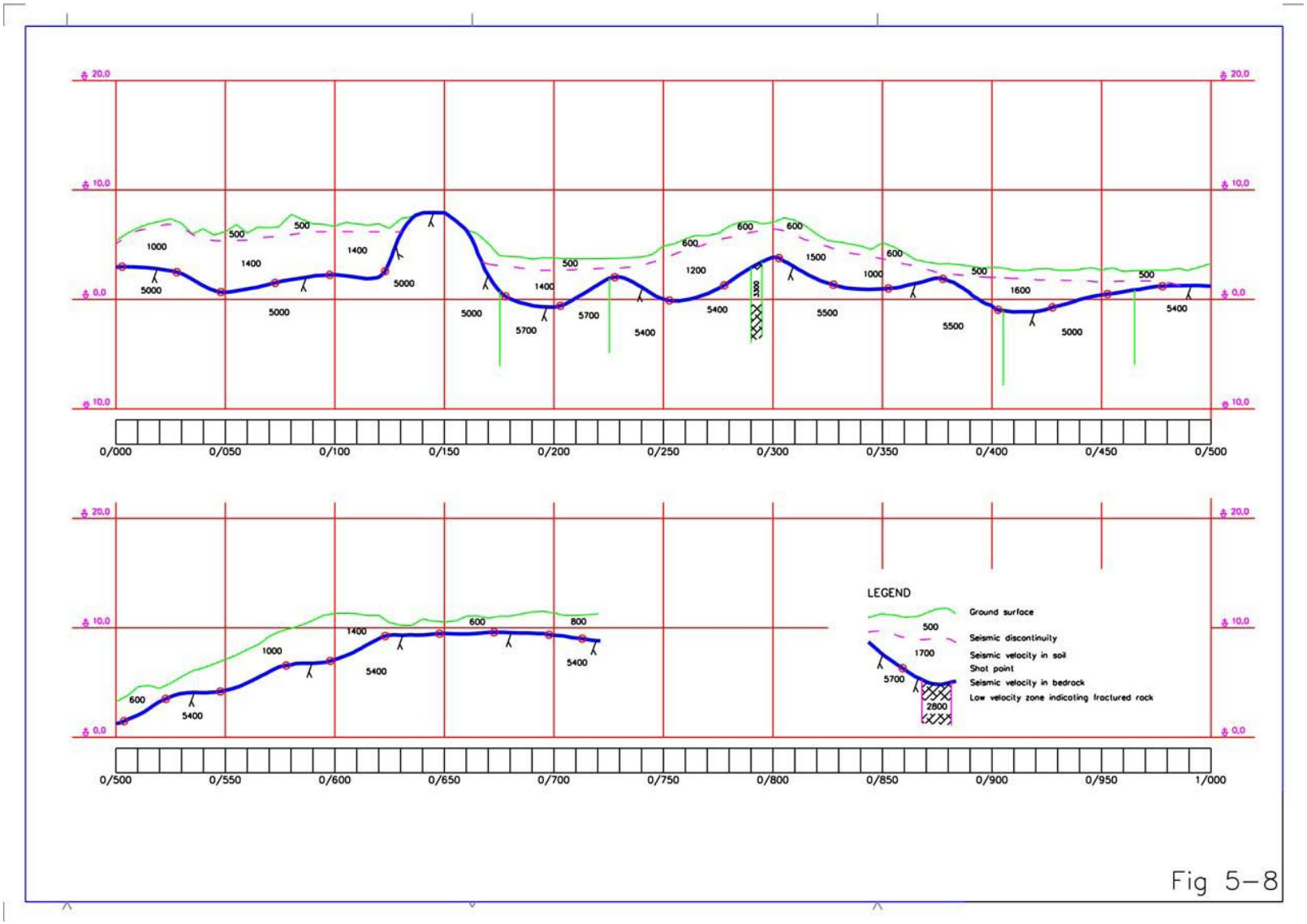

Figure 5-8. *Results from interpretation of refraction seismics in Laxemar. Line LSM000283.*