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ROUND ROCK GEOPHYSICS
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SEISMIC REFRACTION SURVEY FOR SITE CONDITION ASSESSMENT

MULTI FAMILY RESIDENTIAL DEVELOPMENT

8176 NORTH MOPAC EXPRESSWAY

AUSTIN, TEXAS

REPORT FOR:

Ardent Residential

5453 Burnet Road Suite 203
Austin, TX 78756

By: ROUND ROCK GEOPHYSICS, LLC

TBPE FIRM REGISTRATION NO. 50592

FILE NO. 21-0987

August 26, 2021

EXECUTIVE SUMMARY

Introduction

Round Rock Geophysics was requested and authorized to conduct seismic refraction tomography and Multi-Channel Analysis of Surface Waves (MASW) surveys at the project site with address of 8176 NORTH MOPAC EXPRESSWAY AUSTIN, TEXAS for the purpose site condition assessment in relation to the planned multi-family residential development project. These surveys will provide both cross sections and numerical values of the variations of both compressional (P) and Shear (S) wave velocy values. These values are fundamental to assessing the different engineering parameters related to the stability of building foundations and load bearing capacities of the structures. In addition, the can be used to evaluate the condition of the project site in relation to Karst formations.

Brief Description of Seismic Refraction Survey

Seismic refraction survey measures the travel time of the component of seismic energy that travels down to subsurface materials, refracted along the the boundary of materials of different lithology, compaction and/or moisture content, and returns to the surface as a head wave along a wave front as shown in Figure 1 below. The seismic waves which return from the top of a refractors such as a rock surface underlaying soil mass are refracted waves, and for geophones at a different distance from the shot point, represent the first arrival of seismic energy from which Compressional (P) wave velocity values will be computed.

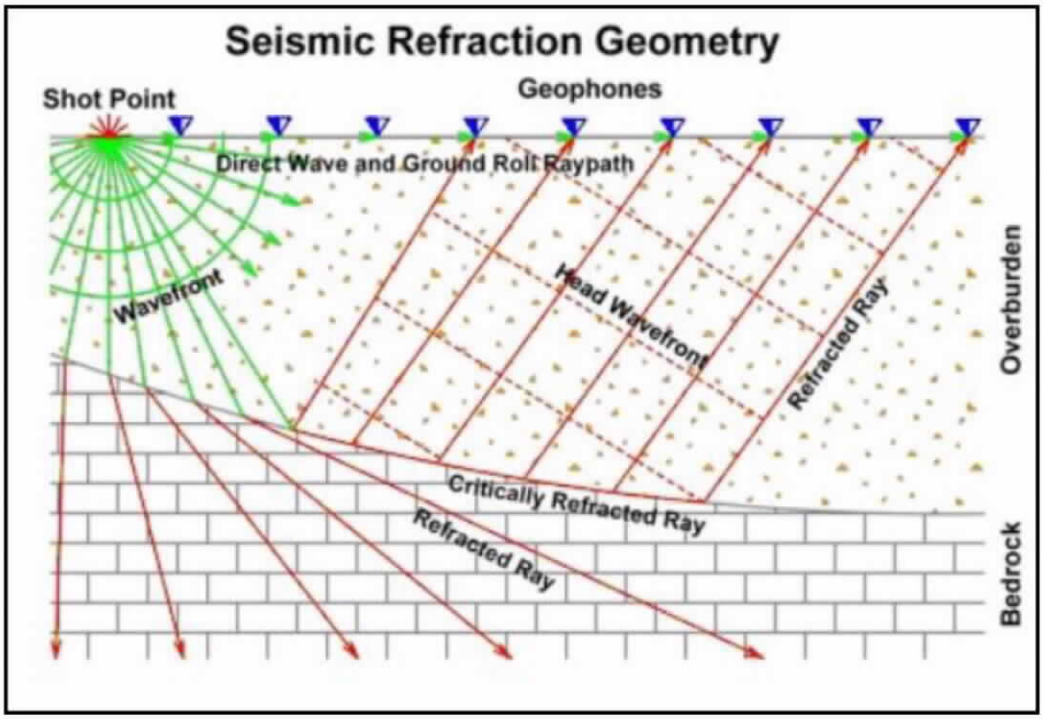

Figure 1: Principles of Seismic Refraction Survey

Brief Description of Multi-Channel Analysis of Surface Waves (MASW)

MASW is seismic method that measures the shear-wave velocity distribution and analyzes the dispersion of surface waves to produce shear-wave velocity (Vs) variations versus depth. These results can be used to estimate soil and rock strength (stiffness), depth and topography of bedrock, map subsurface geology, map low velocity layers and determine IBC Vs100 (Vs30) site classification. Shear-wave velocity (Vs) is one of the elastic constants and is related to Young's and shear moduli. In most cases, it is a direct indicator of the ground strength (stiffness) and is commonly used to analyze load-bearing capacity.

The field data collection procedure is like that of seismic Refraction survey except it requires low frequency vertical geophones and a single shot point offset from the survey line by about twice the geophone spacing. This procedure is explained by Figure 2 below.

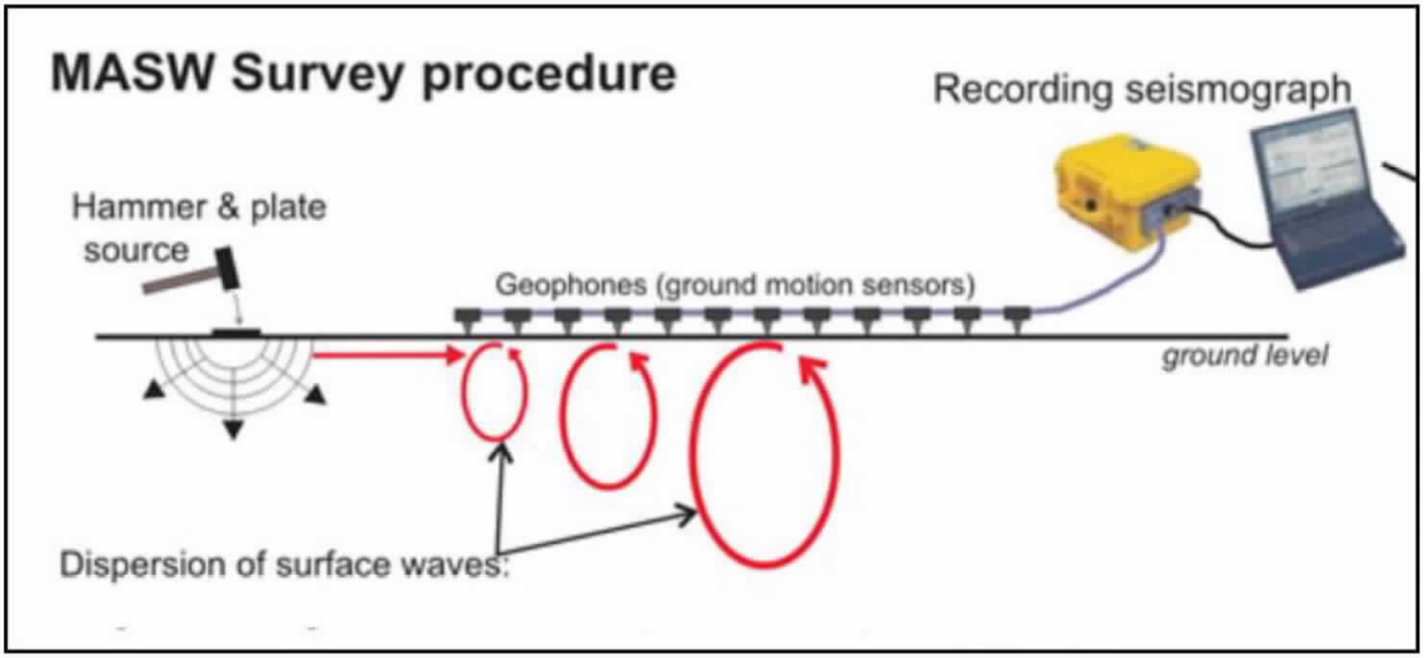

Figure 2: Principles of Multi-Channel Analysis of Surface Waves (MASW) Survey

The Current Seismic Refraction and MASW Surveys

The current seismic refraction and MASW surveys were done along 3 profile lines whose locations and orientations were determined in consultation with the client's representative and based on the overall design plan of the project. These survey lines and their orientations are as shown in Figure 3. The field survey was conducted on August 21st, 2021. The survey design and eventual interpretation of the results were made based on the previously completed geotechnical borehole logs.

The field data collection was done using 24 channel Geode seismograph manufactured by Geometrics, 8 Hz vertical geophones and 12 lb. sledgehammer striking a metallic plate as a seismic source. Geophones were placed at an interval of 8-ft for line 1, and 10-ft for Lines 2 and 3. The MASW data was collected at an offset of 2 geophone spacings. 3 shots were stacked at each shot location for improved data quality.

The field data was processed using Rayfract software from Intelligent Resources and Surfer software package from Golden Software. The MASW data was processed using Surfseis software package from Kansas Geological Survey. The field data processing assumes approximately flat topography along each of the survey lines. The final processed results were able to show cross sections of the P-wave velocity variations along each of the survey lines in sufficient detail to depths of more than 50-ft in Lines 1 and 2 and to 30-ft in Line 3. The MASW survey was able to provide the variation of Shear wave velocity with depth at the center of each of the seismic profile lines.

Interpretation of the results was made based on the previously completed geotechnical drilling logs and other project related information. Accordingly, an approximate relationship was established between the P-wave velocity values and the site's geological formations as shown in Table 1 below. In addition, the P-wave velocity cross sections along each of the profile lines are annotated with the corresponding geological formations as shown in Figures 4-6. As is shown in these cross sections, there is no indication of significant karst formations such as voids or sinkholes along the profile lines. The top layers that are filled with lean clay seem to be cut and fill layers during the site's previous development.

Figure 3: The location and orientation of Seismic Refraction Tomography survey lines

The MASW survey results has shown close relationship between the shear wave velocity values and geotechnical formations. This relationship is shown in Table 2. The values of Compressional (P) and Shear (S) values at the center of each profile are shown in Table. These values can be used to calculate the essential geotechnical parameters such as Young's Modulus, Shear Modulus and Poisson's ratio.

Table 1: Relationship between Geotechnical drilling logs and Compressional (P) Wave Velocity Values

Compressional (P) Wave Velocity Ranges (Ft/sec)	Corresponding geological formations
Less than 8,400	Lean Clay, very stiff and hard
More Than 8400	Limestone with conditions varying from slightly to highly weathered with clay seams and ferrous staining

Table 2

Compressional (P) and Shear (SS) wave velocity values at the center of each profile line

Line	Depth (Ft)	Compressional (P) Wave Velocity (Ft/Sec)	Shear (S) Wave Velocity (Ft/Sec)
Line 1	-3.683	4866.582518	2059.015
	-8.287	6600.069211	1781.984
	-14.041	7160.824392	1831.08
	-21.234	9169.612483	2065.873
	-30.225	10937.73659	2329.794
	-41.464	12860.04512	3308.783
	-55.513		3938.517
	-73.074		3738.998
	-95.025		3932.612
	-118.781		6378.733
Line 2	-3.338	5914.444403	4143.558
	-7.511	9227.70578	4286.115
	-12.727	11114.81955	4741.035
	-19.247	11795.56723	5039.592
	-27.397	8633.265925	4984.669
	-37.584	8568.986409	4152.808
	-50.318	12771.83174	3086.075
	-66.235		3495.66
	-86.132		4458.988
	-107.665		5196.021
Line 3	-3.116	9263.969086	3084.827
	-7.01	12692.04403	3214.711
	-11.878	14293.24747	2769.771
	-17.963	17883.58517	2679.319
	-25.569	19022.75442	2678.584
	-35.077	9263.969086	3468.575
	-46.962	12692.04403	4262.601
	-61.818	14293.24747	4875.993
	-80.388		4833.232
	-100.485		4770.421

Conclusion

The current seismic refraction tomography and MASW surveys were able to provide compressional (P) and Shear (S) wave velocity values of the project site to maximum depth ranges of 60-ft to more than 100-ft below ground level, respectively. The survey results were able to provide the cross sections of the P wave Velocity values and 1D plot of Shear wave velocity variations at the center of each profile line. Approximate relationship was established between these parameters and corresponding geological formations. This close relationship is summarized in a table and presented as crosse sections along each profile line for the seismic refraction tomography surveys.

In addition, the numerical values of both Compressional and Shear waves are presented and can be used for calculation of geotechnical parameters in relation to structural design and site assessment.

The final interpreted results have shown no indication of significant Karst formation of concern like large size void or sinkhole, at least along the profile lines to the maximum depth of exploration.

Closure

This report was prepared in accordance with generally accepted geophysical survey practices. No other warranty is expressed or implied. The data and analysis presented in this report are based on the available project information. We appreciate the opportunity to provide you our services. For any question or comments about this report, please contact us with the following:

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RESULTS: SEISMIC REFRACTION TOMOGRAPHY AND MASW SURVEYS

Figure 4: Seismic Refraction Tomography Survey Profile 1

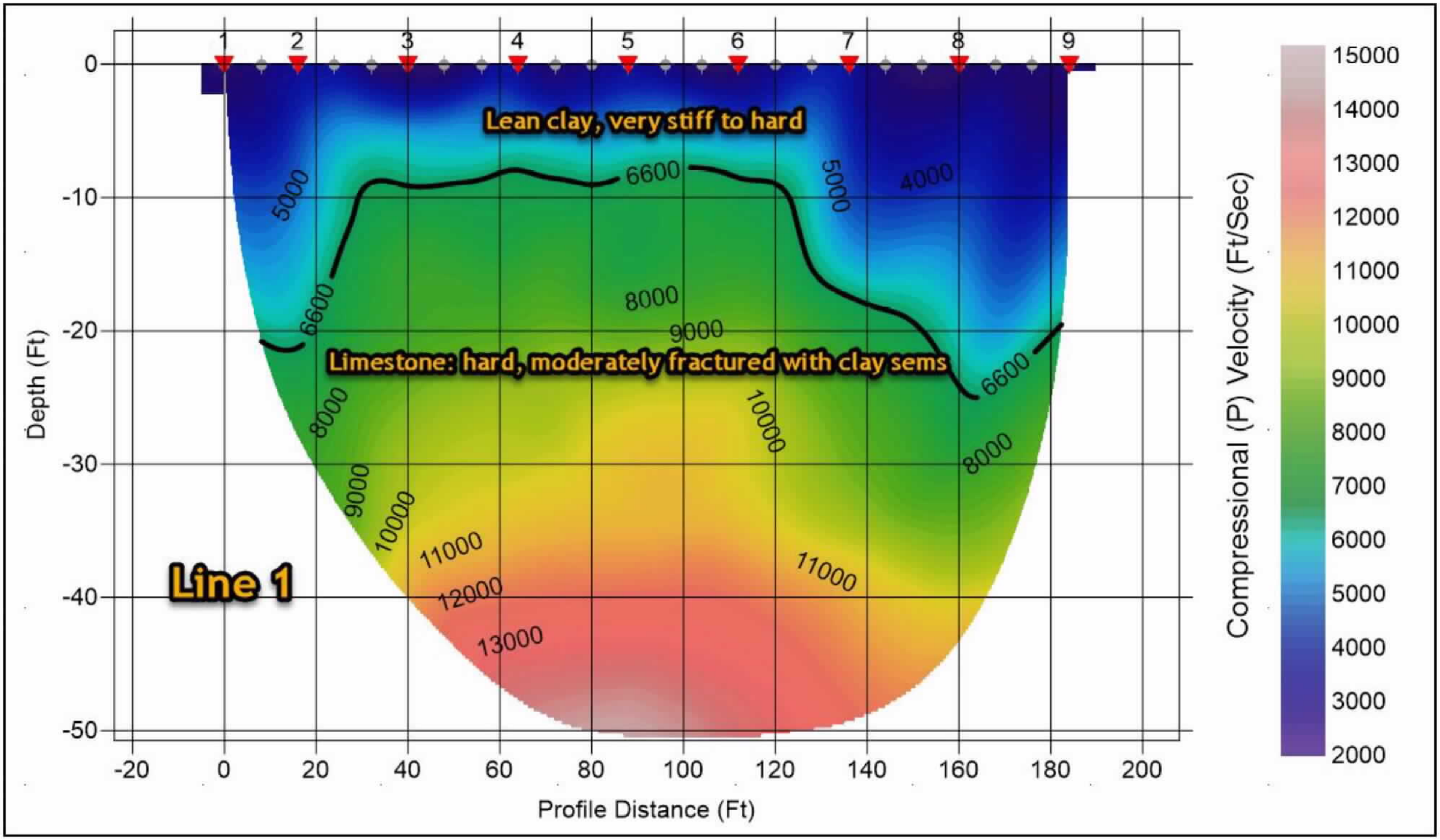

Figure 5: Seismic Refraction Tomography Survey Profile 2

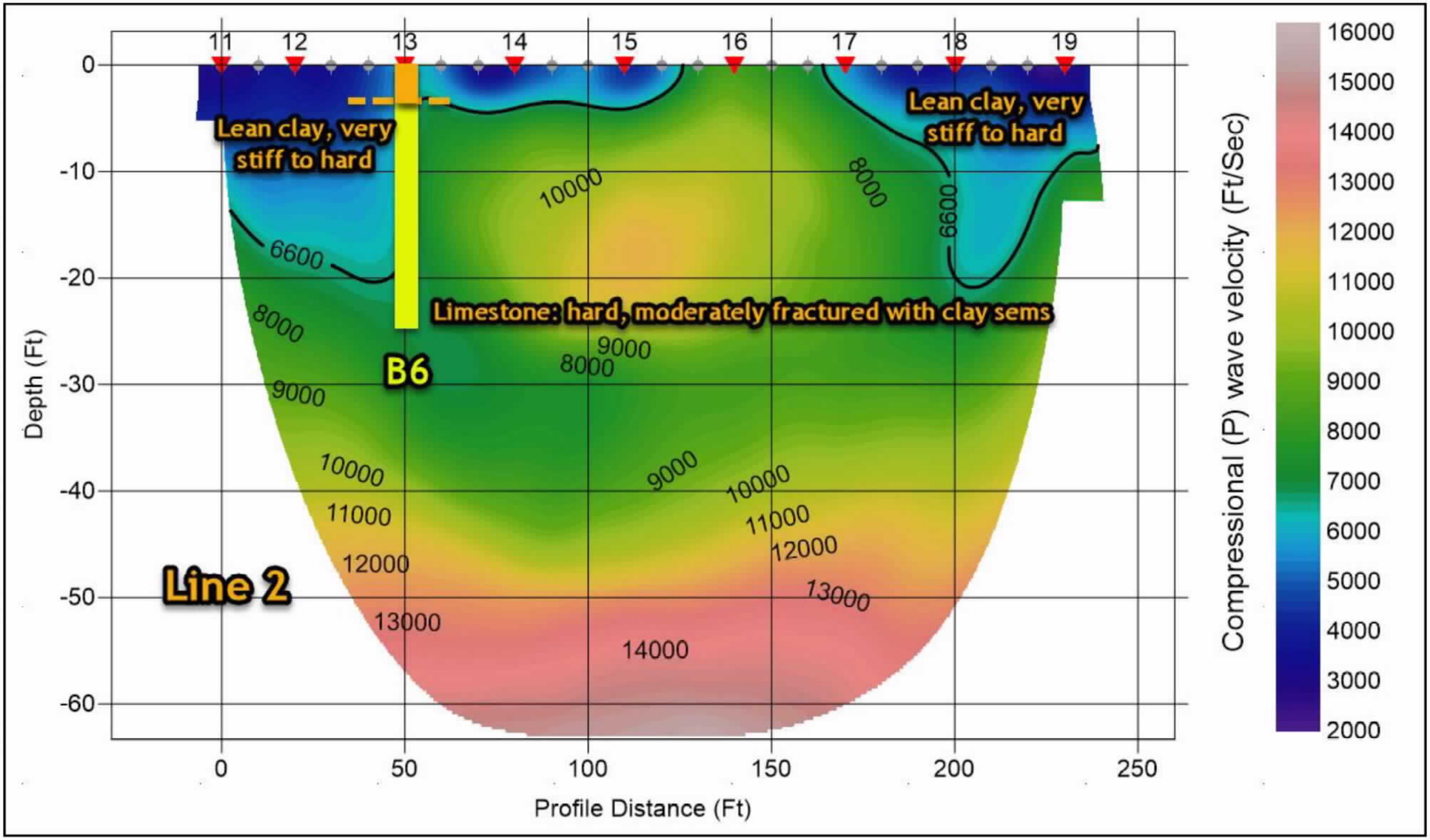

Figure 6: Seismic Refraction Tomography Survey Profile 3

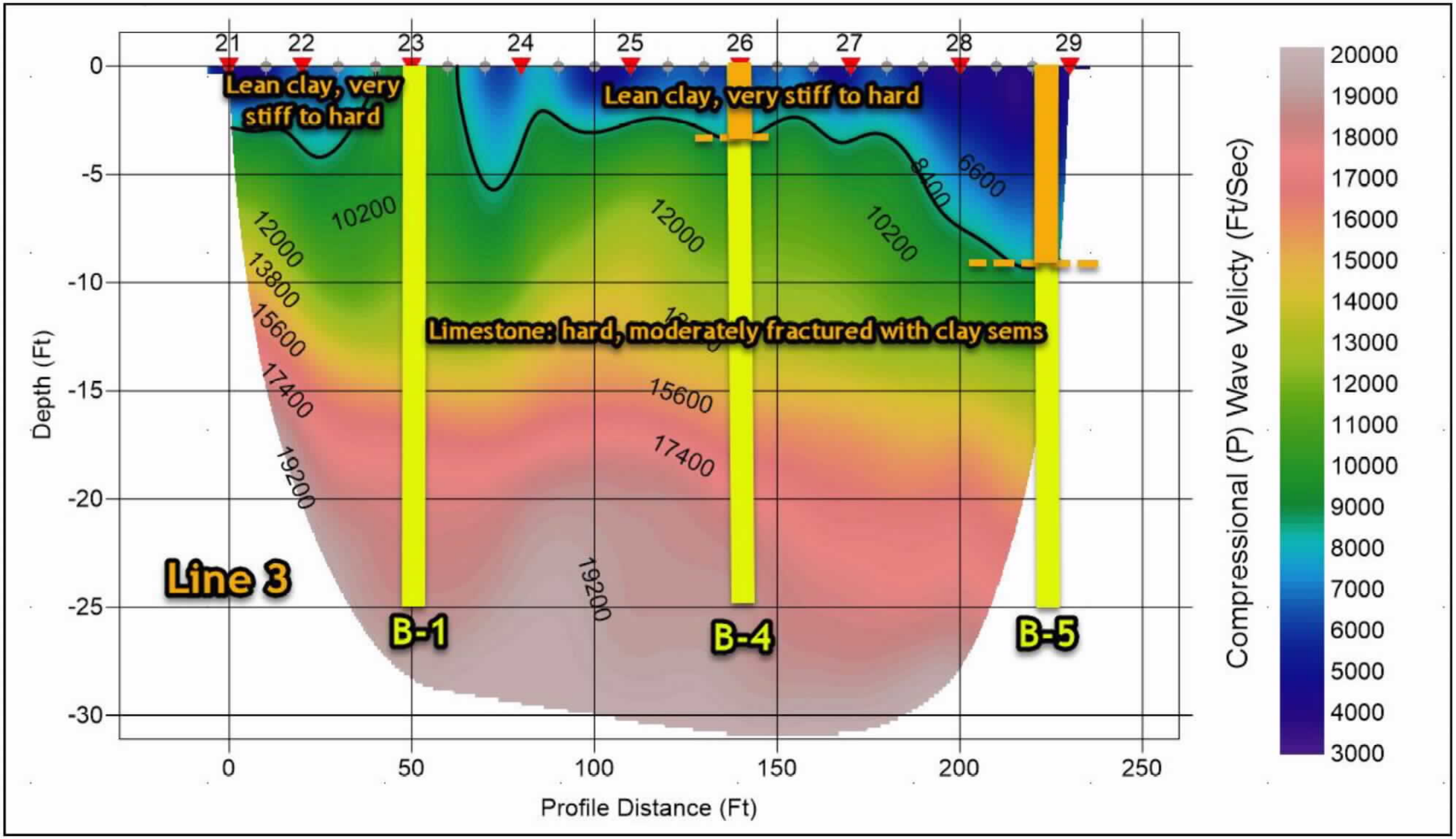

Figure 5: Seismic Refraction Tomography Survey Profile 3

Figure 6: Multi-Channel Analysis of Surface Waves (MASW)-Profile 1

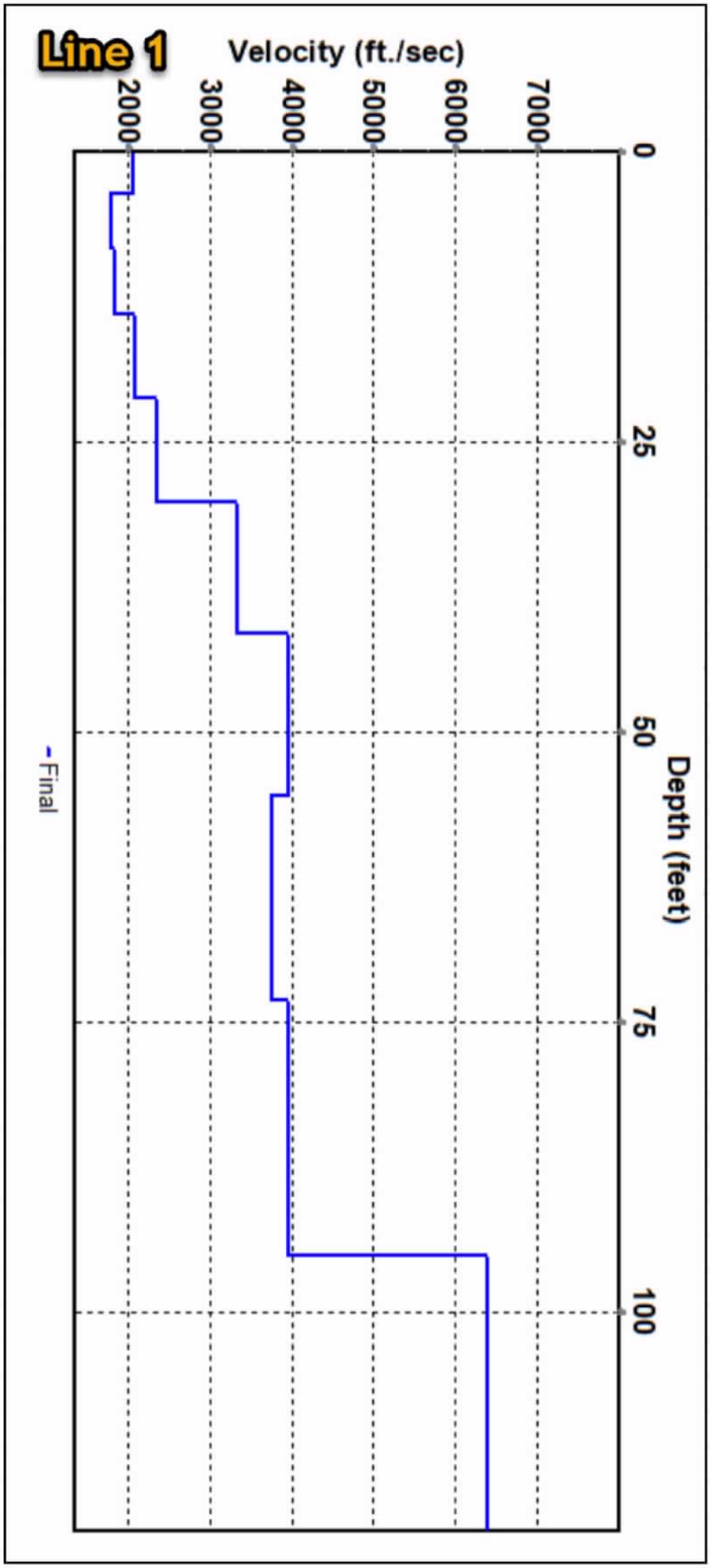

Figure 7: Multi-Channel Analysis of Surface Waves (MASW)-Profile 2

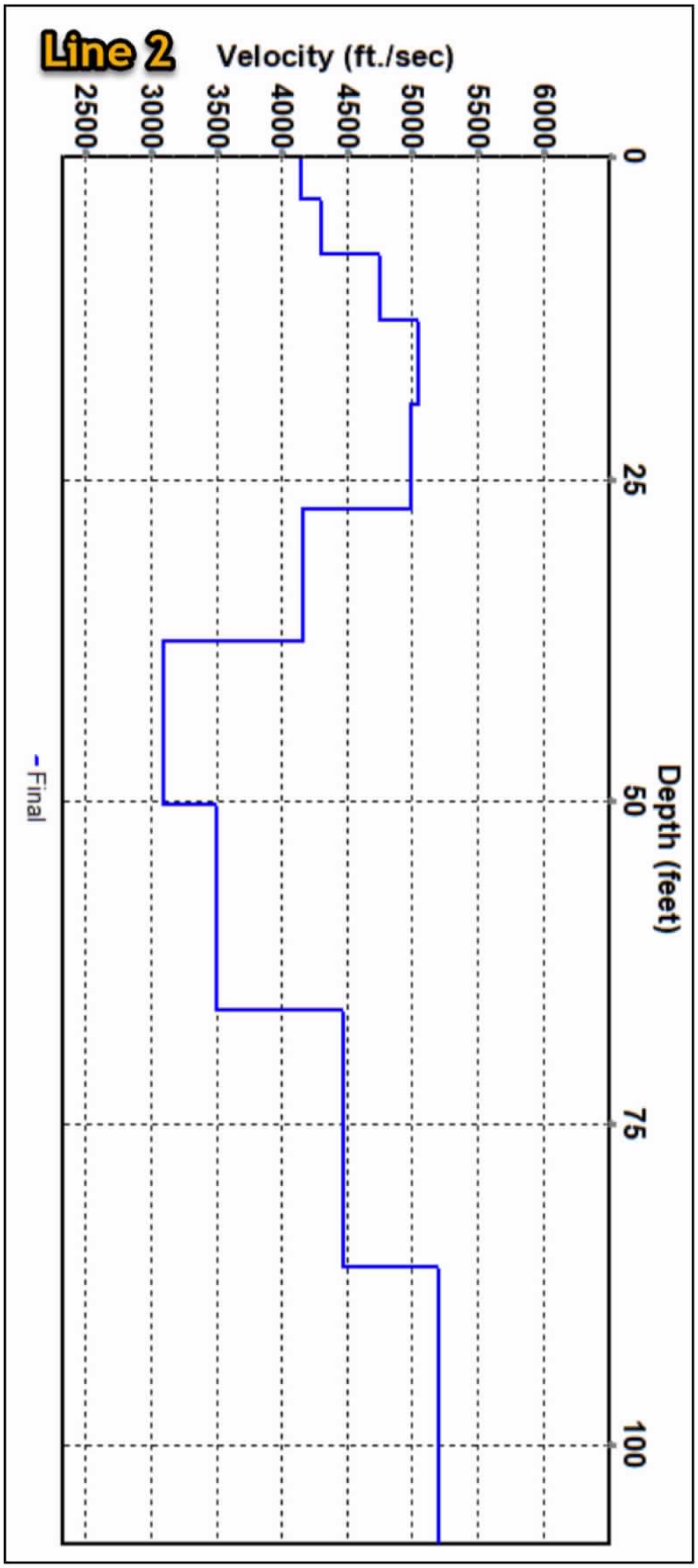

Figure 7: Multi-Channel Analysis of Surface Waves (MASW)-Profile 3