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EFFECT OF LINEAR AND NON-LINEAR GEOPHONE ARRAYS ON SIGNAL-TO-NOISE RATIO OF SEISMIC REFLECTION DATA

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Abstract

We used linear and non-linear geophone arrays to attenuate the coherent noise seen on single-sensor data recorded in a seismic reflection project performed in the Dumitresti area, Romania. We compared the responses of linear geophone arrays with 12 elements with those of non-linear geophone arrays (rectangular, circular, cross and fishbone patterns). We showed that the non-linear arrays with circular, cross and fishbone patterns perform the lowest attenuattion of the coherent noise.

Introduction

Land seismic reflection data contain coherent noise (surface waves) which can be strongly affected by spatial aliasing, depending on the near-surface conditions and data aquisition parameters. The spatially aliased energy affects the accuracy of the filtering and migration results. This coherent noise can be attenuated during data acquisition using hard-wired geophone arrays directly in the field or computing the array responses using seismic data from single-sensor measurements before the data processing (Panea and Drijkoningen, 2008). Panea (2009) showed that the use of hard-wired arrays in areas with rough topography and variations in the near-surface conditions can destroy the signal wavelet with effects on the velocity and amplitude analysis.

Designing of the linear and non-linear geophone arrays

We display in Figure 1a, a linear geophone array with 12 elements. In our analysis, the group interval, ΔX_G, is equal to $2\Delta X_g$, the spacing between the array elements on the inline and crossline direction. The group interval represents the distance between the centers of two consecutive geophone arrays; it is chosen such that the reflected waves will not be spatially aliased after array forming. The non-linear geophone arrays are displayed in Figures 1b-e. We designed these arrays based on the pattern used in the field for single-sensor measurements.

Description of the single-sensor seismic data

We used seismic data recorded in the Dumitresti area, Romania, in an international research project performed to obtain information about the geological structure of the subsurface. The data acuisition was performed using a strip of five lines with receivers spaced at 5 m on both directions, inline and crossline.

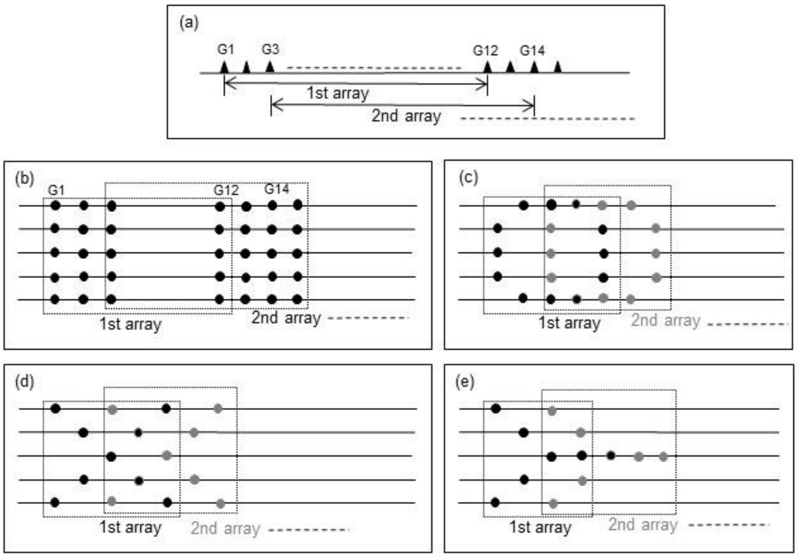

Figure 1: Linear and non-linear geophone arrays

Each receiver was represented by 12 vertical-component geophones planted in a rectangular nest (4×3 geophones). The variations in elevations were important along the seismic line (Figure 2). The maximum number of receivers/record was 160. The seismic energy was generated using explosive sources (dynamite) in points spaced at 20 m and placed only along the third line. The time sampling interval was 0.001 s. The maximum length of recordings was 4 s.

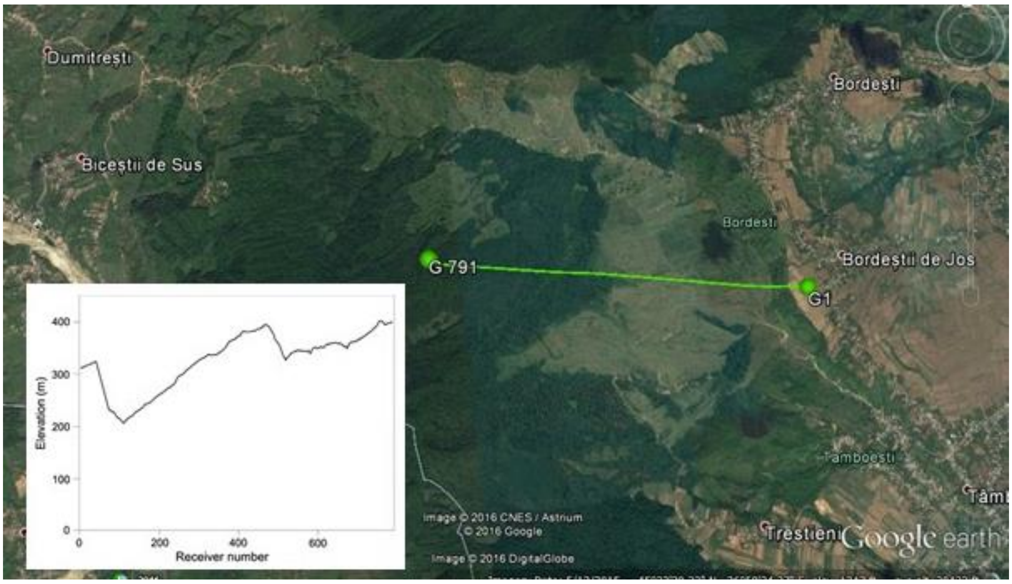

Figure 2: Topographic map for the Dumitresti area, Romania, showing the seismic line (green line); inset: elevation variations along the line. Source map: http://maps.google.com.

An example of raw single-sensor record is displayed in Figure 3a. The surface waves cover the reflected waves at small offsets; they show strong energy in the (f,k)-domain (Figure 4a). The surface waves are well attenuated using linear arrays with 12 elements (Figures 3b and 4b). Good attenuation was performed by the rectangular array with 12×5 elements (Figures 3c and 4c). Lower attenuation of surface waves was observed after array-forming with circular, cross and fishbone patterns (Figures 3d-f and 4d-f).

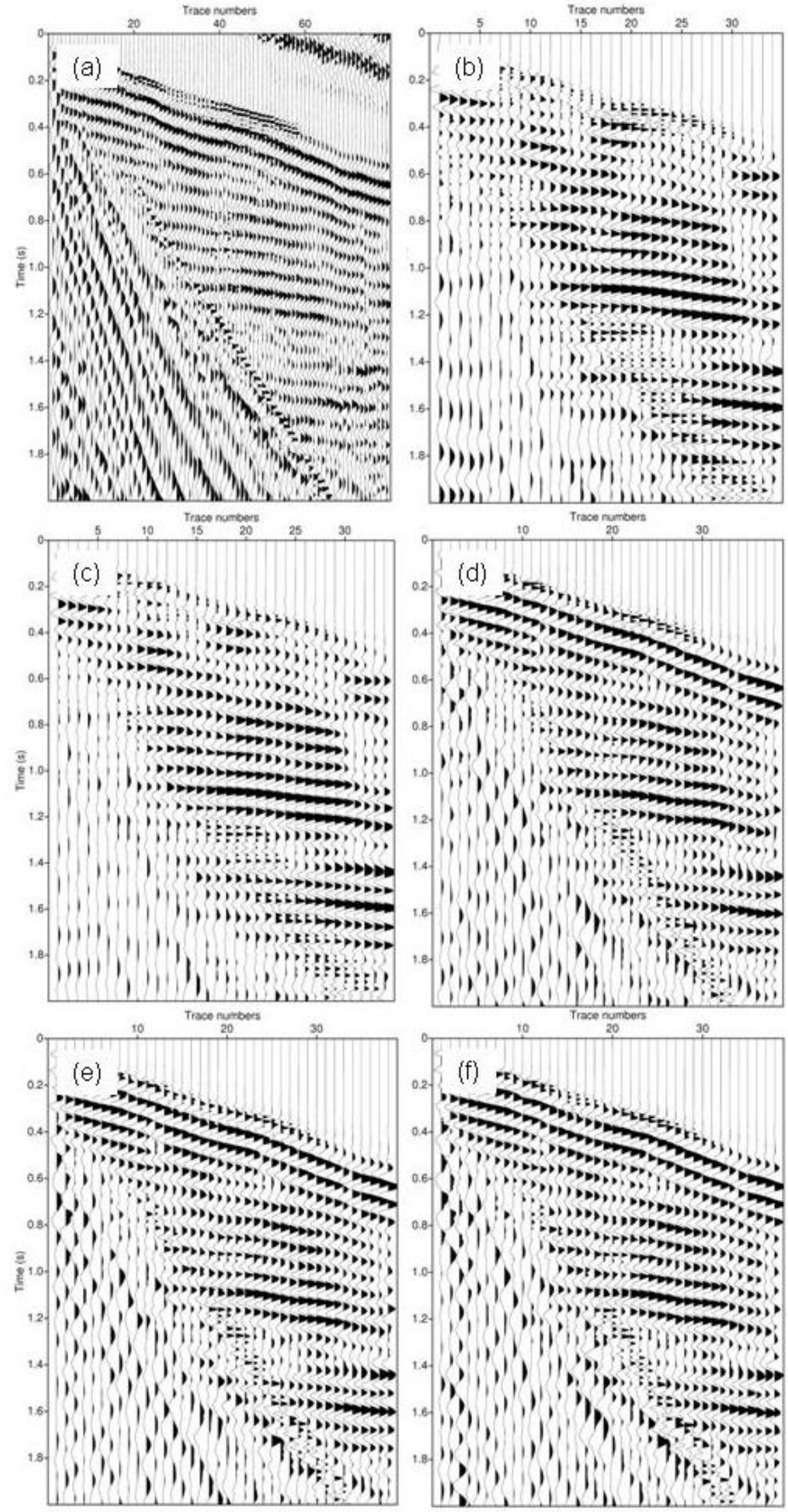

Figure 3: (a) Raw single-sensor record after (b) linear, (c) rectangular, (d) circular, (e) cross, (f) fihsbonse array-forming displayed in the (t, x)-domain.

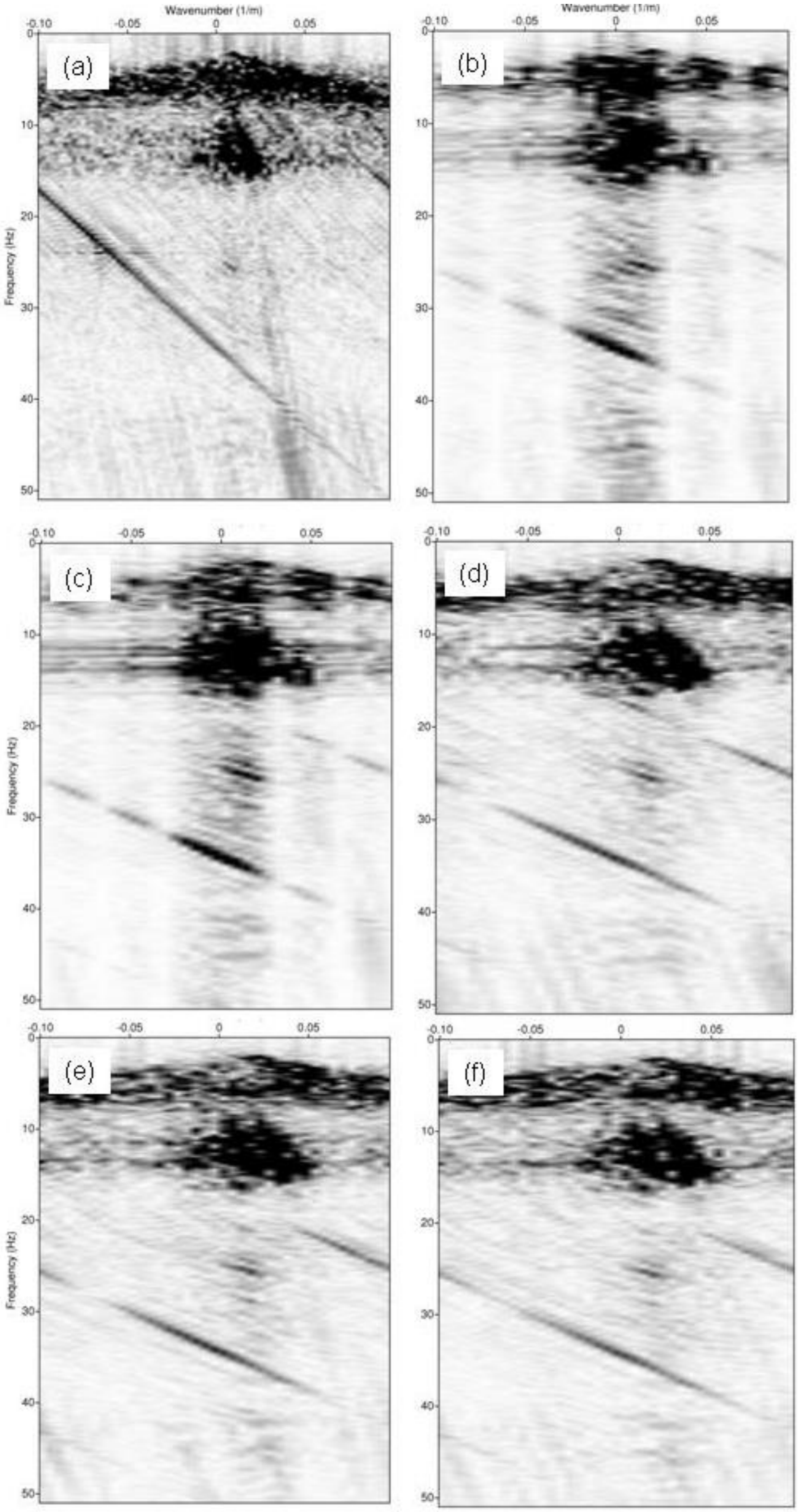

Figure 4: (a) Raw single-sensor record after (b) linear, (c) rectangular, (d) circular, (e) cross, (f) fishbone array-forming displayed in the (f, k)-domain.

Conclusions

We compared the attenuation of the surface waves seen on single-sensor land seismic reflection data performed by linear and non-linear geophone arrays. The best attenuation was peformed by the linear and rectangular arrays. Lower attenuation was observed on the circular, cross and fishbone array-forming responses displayed in the (t,x)- and (f,k)-domains.

References

Panea, I., Drijkoningen, G. (2008). The spatial data-adaptive minimum-variance distortionless-response beamformer on seismic single-sensor data. Geophysics, 73(5), Q29-Q42.

Panea, I. (2009). Array forming in the presence of phase variations. The Leading Edge, 28(2), 216-221.