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Field evaluation of a helical fiber-optic cable for near-surface seismic acquisition with DAS

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Summary

No summary.

Introduction

Distributed Acoustic Sensors (DAS) offer new capabilities with regards to seismic acquisition (Parker et al., 2014). DAS systems with straight fiber optic cables have high sensitivity towards P-waves traveling along the fiber, so DAS is most widely used for Vertical Seismic Profile (VSP) surveys, where the cable is placed in a well (Mateeva et al., 2017). Straight DAS cables can be used for the near-surface acquisition in the smart DAS uphole acquisition technology, where the same cable is placed along the surface and in shallow wells – these vertical segments in the shallow wells contribute to the reflected wave imaging (Bakulin et al., 2017). In principle, using DAS for surface seismic surveys offers multiple advantages over more traditional sensors (Bakulin et al., 2020). However, to use horizontal fiber optic cables only on the surface (or slightly buried under the surface for better signal-to-noise ratio (SNR)) for surface seismic, the DAS cable needs to be sensitive to P-waves traveling normal to the fiber. Helical cables are one of the proposed solutions to improve such broadside sensitivity (Kuvshinov, 2016). Such cables were tested in the field and their broadside sensitivity was proven, however several questions remain with regards to their coupling, in particular strong seasonal variations of buried cables' sensitivity were demonstrated (Tertyshnikov et al., 2020).

We aim to investigate the applicability of such helical fiber optic cables in the near-surface seismic acquisition. We recorded a small seismic dataset acquired in parallel with geophones and helical cables placed along a 500 m line and performed initial processing of such data. The brute stacks show comparable quality of resulting seismic images.

Method

A 2D seismic line was acquired along a 500 m-long trench (approximately 20 cm deep) where several DAS cables were buried. For this test, we use the data from a 60-degree helical DAS cable. The DAS system provides the data with 1 m spacing, 10 m gauge length and 5 m pulse width. A geophone line with 2 m sensor spacing was placed on the surface next to the trench, which was used for the computation of a reference image. Shot points with 2 m spacing were acquired along the line by a vibroseis seismic source with 6-150 Hz linear sweep.

The geometry was set up taking into the account the wrapping angle of the helically wrapped cable. Common-midpoint binning with 1 m midpoint spacing was applied. The same grid was used for both datasets. For brute stack computation, a 1D velocity model was used, which was estimated on a CMP supergather. Before stacking, automatic gain control with 500 ms window was applied together with a 20-30-150-250 Hz Ormsby bandpass filter for the attenuation of surface waves. Stacking with 30% NMO stretch mute was performed. No statics and no specific procedures for attenuation of linear noise were applied at this stage in order to avoid introducing any differences in the stack quality caused by processing. After stacking, a time derivative of the geophone stack was computed for easier comparison with the DAS dataset in terms of phase and amplitude spectra.

Results

Figure 1 shows a comparison of brute stacks obtained with geophones and the DAS system. Reflections from the same layers can be seen on the two images (green arrows) down to approximately 700 ms. The image obtained with DAS sensors appear to have higher level of noise, which is particularly visible in the zones of lower fold at the edges of the survey (red arrows). It is important to note that the lower noise level in the geophone image is in part caused by the fine geophone spacing – traditional seismic surveys are acquired with much more sparse geophones, while for DAS small spacing comes at no cost except for the data storage. The comparison of the image acquired with DAS with the one obtained with conventional 25 m geophone spacing is the subject of the further research.

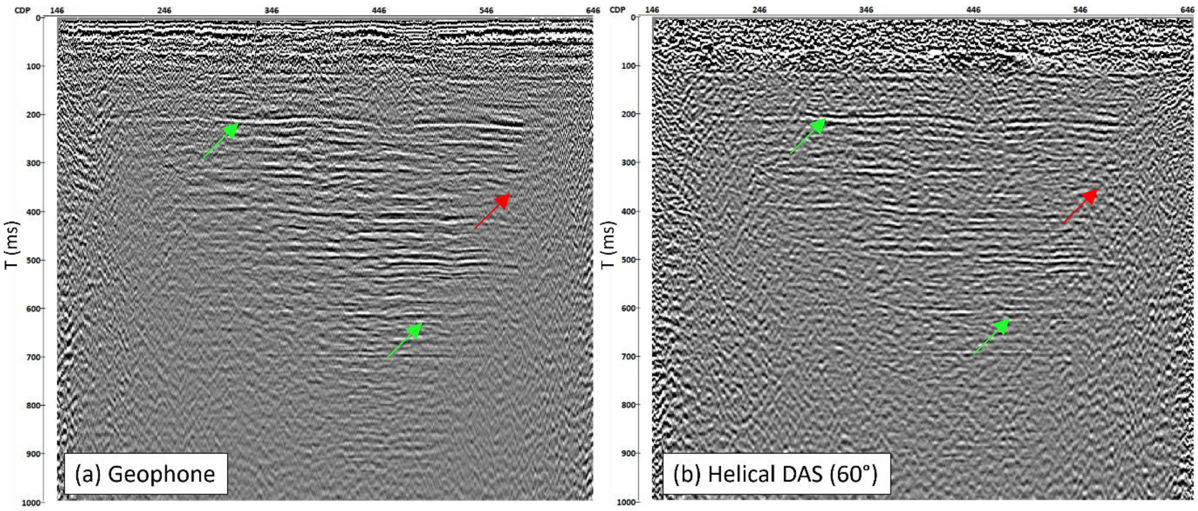

Figure 1 *Comparison of brute stacks acquired with (a) geophones and (b) 60° helically wrapped DAS cable. The green arrows show the reflections. The red arrows show low-fold area with lower SNR.*

Conclusions

We obtained initial images for a near-surface 2D seismic survey acquired in parallel with geophones and a DAS system connected to a helical 60-degree fiber-optic cable. The presented results show that comparable near-surface seismic image quality can be obtained with geophones and DAS sensors with helical cables. We still qualitatively observe a lower noise level for the geophone image, however this image was obtained with very fine 2 m geophone sampling, while DAS offers high flexibility in terms of survey design after the cable deployment, and naturally provides fine spatial sampling (1 m in this case). Comparing DAS to more traditional sparser geophone configurations is the next step of the research.

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