Trialling distributed acoustic sensing in a sand dune environment

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SUMMARY

Sand dune is known as sand grains and it is formed and accumulated by wind. Sand Dunes can be found in many regions such as Rubaii Alkhali in Saudi Arabia and sub-Sahara Africa. Distributed acoustic sensing (DAS) is a new technology that can be applied for detecting acoustic waves using a fiber-optic cable. The objectives of this study are to compare different methods of acquisitions in order to image the near surface covering with very loosy sand dunes. We used the conventional seismic acquisition method and DAS. In addition, we used in this test different kinds of DAS cables with different depths over the sand.

Key words: Conventional seismic acquisition, distributed acoustic sensing (DAS), sand dune

INTRODUCTION

Imaging high resolution near surface of very complex and loosy sand dunes is one of the most challenging tasks. Sand dune is known as sand grains and it is formed and accumulated by wind. Sand Dunes can be found in many regions such as Rubaii Alkhali in Saudi Arabia and sub-Sahara Africa. Distributed acoustic sensing (DAS) is a new technology that can be applied for detecting acoustic waves using a fiber-optic cable. DAS has emerged as an alternative to geophone recording. The process uses fiber optic cables and an interrogator that transforms the detected strain changes along the cable caused by vibrations in the surrounding medium to point signals reflecting such vibrations as a function of time. Its primary succuss is associated with recording in a well, as such conventional cables measure sensitivities of the medium along the cable direction, providing vertical wells, with vertical component measurements (Mestayer et al., 2011; Barberan et al., 2012; Cox et al., 2012; Daley et al., 2013; Mateeva et al., 2014). Along the Earth surface DAS has been utilized to extract surface waves from active source or ambient noise. Their horizontal component recording provides the information need to invert the surface waves and yield Shear wave velocity information (Feigl et al., 2017; JREIJ et al., 2018)

In this work, we intend to characterize the near surface of sand dunes by utilizing different sensing systems and methods. In order to achieve our objective, we compared two different techniques that are conventional seismic sensing and distributed acoustic sensing (DAS). We utilize different types of DAS cables with different deployment depths. In the desert, seismic exploration contains many features such as sand dunes and buried Wadis. These kind of features are a challenge. Therefore, we examine different approaches for seismic data acquisition and processing to obtain a high quality data and hence the results may lead to a new invention in such environment.

METHOD

Sa'ad Area is located about 100 kilometers north-east of Riyadh City (Figure1). This area is characterized by very loosy sand grains with very static sand dunes (Figure2). We aquire seismic data using two methods: conventional seismic data acquisition and distributed acoustic sensing (DAS). We places a spreading line of geophones parallel with fiber optics cables over sand dunes area. The layout of the DAS cable combines vertical and horizontal elements with an innovative mechanism of layout and placement. We target configurations, which allow such layout to provide multi component data by these both systems.

In Conventional seismic acquisition, high-resolution seismic data were acquired over a distance of 500 m as shown in Figure 2. We used 96 geophones, the group interval between geophones was 5 m, and the spacing between the shots points was 10 m. We used Minin IVI vibrosies with sweep bandwidth (20-100Hz) and one sweep for each station. Figure 2 shows DAS system and cables layouts, we test different type of cables to help in assessing the sensing of these types of cables for sand dunes and comparing the results with the conventional seismic. We layout three different cables. First, Indoor simplex F.O. cable (Yellow cable), the length of this cable was 1000 m in total. We buried the cable over a 15 cm deep, the trench was 500 m in length, and the rest of the cable was on the surface and parallel to trench. Second, Fiber single mode cable (Black cable), the length of this cable was 1000 m. We dug 1.2 m deep trench to accommodate the cable, the length of the trench was 500 m, and the remaining 500 m of the cable was on the surface and parallel to trench as we did with yellow cable. Lastly, bare fiber optic cable (Blue Cable), we also placed only 500m of the cable along the lines cover with a bit of sand. Figure 3 presents raw data example for geophone and 3 m gauge length (10) and 10 m gauge length DAS units.

We processed the data using the conventional processing work follow for seismic reflection data with taking into account the condition of the near surface. The data were very noisy with very high ground. We applied elevation statics to the data, to take into account the roughness of the topography. Then, after filtering the ground-roll and multi-refracted events, we manage to clearly pick the reflections at the base of the sand layer. In the PSDM, this surface is the first reflected event below the free surface in Figure 3. This event indicates that the thickness of the shallowest layer vary between 8m and 12m, and its average velocity is about 1400 m/s (see Figure 4). We decided to don't apply residual statics for the following reasons: the first breaks at short offsets are very difficult to be picked on many shots. We estimated the average time origin to be 250ms. We did Static corrections to eliminate the time bulk shift of 250 ms, constant for all the shot ensembles. The shallow reflections can be picked clearly and therefore possible to follow the shallow lateral velocity variations. We filtered the data with trimmed mean dynamic dip filter (TMDDF) with corner frequencies 5, 10, 200, 400 Hz to mitigate noise and to improve the quality of data especially in the very near surface. Figure 4 shows the Pre-Stack migrations, in time and depth, with greatly improves the quality using the TMDDF filter.

DAS OBSERVATIONS

Main findings from the survey are summarised below:

- All cables (telecommunication, tactical and the bare fibre) allowed to record the seismic wavefield. As expected, the record is dominated by the ground roll, but some body wave energy is also present.
- Deployment of the fibre optic cable in sand dunes is not very complicated due to the softness of the media. It can be done using standard machinery developed for burying telecommunications, but, in fact, much more compact machines can be developed.
- As we see the response on even the cables laying on the ground it seems to be feasible to develop hybrid fibre/geophone cabled systems which would have geophones to target body waves and fibre – to target surface waves (which can be used for near surface characterisation). There are also potential benefits in concurrent measurement of strain (through DAS) and components of the particle velocity (geophones) to characterise the medium.
- Bare fibre surprisingly behaved well as a seismic receiver in sand dune environments, surprisingly it turned out to be feasible not only to deploy, but also to retrieve the bare fibre without breaking it. It should be possible to use sand as a media which could support the bare fibre and deploy it using different configurations
- Different components of the wavefield, which would correspond to different wavenumbers on the DAS record have different optimal gauge length settings. For instance, we demonstrate that high frequency slow surface waves with phase velocities of ~150 m/s are not recorded on 10 m gauge length system. As such, to record full seismic wavefield we need to acquire data with multiple gauge lengths by either using several DAS interrogators concurrently or opting for systems allowing either change gauge length or record multiple gauge lengths concurrently.

CONCLUSIONS

Distributed acoustic sensing (DAS) provides a favourable platform for acquiring surface seismic data on Sand dune surfaces. The cable nature of the measurement allows for a larger manageable surface of coupling needed with loose Sands. A 10-m gauge length provided higher signal noise ration favourable to low frequency data, like surface waves. It also degraded the resolution causing some of the lower velocity high frequency surface waves, that showed up in the 3-m gauge-length measurement to be attenuated. This favors acquiring data at multiple gauge-lengths to enhance different frequencies. A detailed comparison between the conventional recording and DAS will be shared at the meeting.

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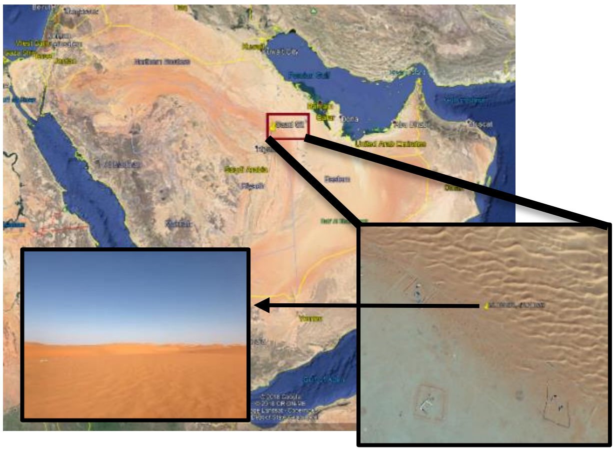

Fig. 1. **Saad Area locates north-east of Riyadh.**

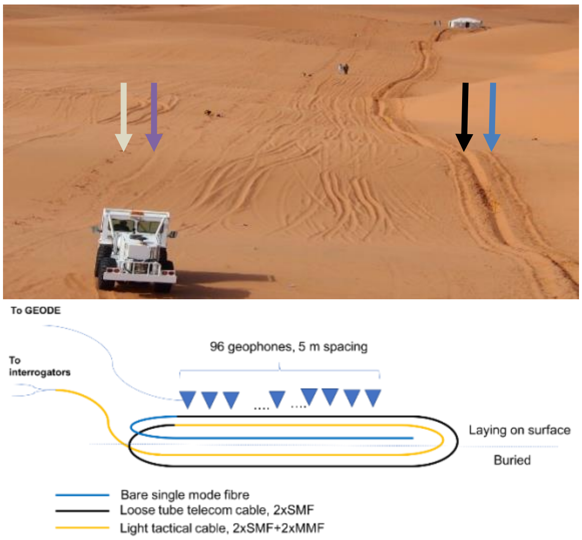

Fig. 2. Cable and geophone layout scheme. Two systems of a conventional seismic line and DAS cables are shown in the figure. Also shown is the conventional seismic line (gray arrow) with 96 channels. DAS cables are buried into different places to cover most of the study area.

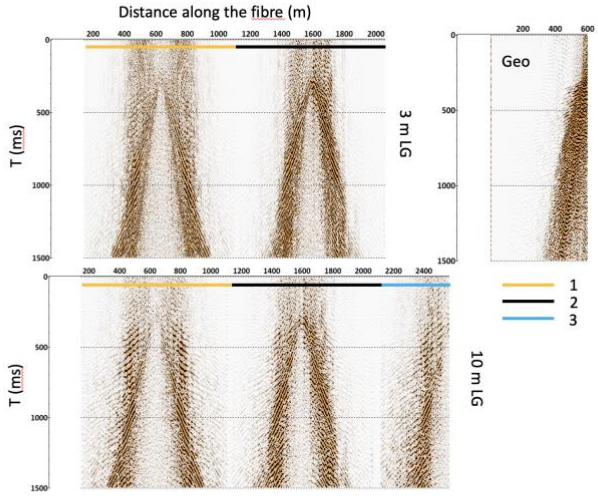

Fig. 3. Raw data example for geophone and 3 m gauge length (10) and 10 m gauge length DAS units. Note that fibre forms one continuous line comprised of tactical (1), telecom (2) and bare fibre (3, for 10 LG unit only). The shot is at the end of the line.

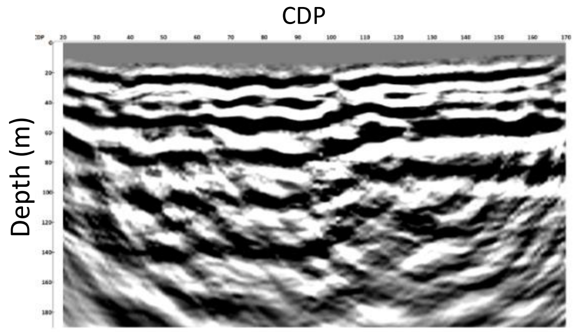

Fig 4. The pre-stack depth migration with a TMDDF filter, which adds a great improvement and enhances the quality of the final imaging.