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Please fill in your abstract title.	Velocity Estimation and Imaging Using Walkaway DAS VSP Acquired with Carbon Rod

Please fill in your author name(s) and company affiliation.

Given Name	Surname	Company
Ali	Aldawood	Saudi Aramco
Ilya	Silvestrov	Saudi Aramco
Maxim	Dmitriev	Saudi Aramco

Abstract

Providing highly resolved seismic images is one of the main challenges facing seismic processing. Vertical seismic profiling (VSP) datasets are utilized to obtain higher resolution images in the vicinity of boreholes. Recently, borehole seismic datasets have been acquired using the more cost-effective distributed acoustic sensing (DAS) fiber-optic cable compared with conventional borehole geophones. Our objective is to design a processing and imaging workflow of a DAS walkaway VSP dataset to optimally utilize the large number of recorded traces typically available in DAS datasets to enhance signal-to-noise ratio (SNR) and image the target reservoir.

We have acquired a novel DAS dataset using optical fiber embedded in a carbon fiber rod. While carbon rod is typically used for flow noise measurements with DAS, we have acquired a walkaway VSP survey to evaluate carbon rod DAS VSP for velocity estimation and imaging applications. Despite the lower signal-to-noise ratio (SNR) of the DAS dataset compared to conventional geophone data, the recorded VSP wavefield is spatially sampled much more finely (1700 vs. 200 stations), which could compensate significantly for the lower SNR. DAS data is output at 1 m receiver station sampling. A sliding-window supergrouping technology is utilized in the common-receiver domain to enhance the SNR of the prestack DAS data. Then, a tomographic inversion of first-break arrival times, extracted from the enhanced supergrouped gathers, is applied to obtain a smooth migration velocity. A median dip filter is applied to the DAS dataset to extract the reservoir reflection events in all common-shot gathers. Lastly, linearized full-waveform inversion (i.e., least-squares migration) is used to invert these reflection data and obtain a representative subsurface image of the target reservoir.

Test results on the field DAS VSP dataset show the possibility to illuminate a deep target reflector using the DAS VSP data, which has a quite low SNR. In addition, our proposed preprocessing workflow enhances both the first arrival waveforms and reflection events in the data domain. This has significantly improved our ability to perform first-break traveltime tomography and least-squares migration. The migrated image ties well with the formation tops, and the well logs, and successfully extends the target horizon image laterally up to 600 meters away from the well.

Our results demonstrate the feasibility of acquiring walkaway VSP datasets using the DAS fiber inside carbon rod. These datasets can be acquired jointly with flow noise measurements in injectors and producers, and are more cost-effective compared with conventional borehole geophone data. Our novel processing flow has the potential to improve the quality and the resolution of the inverted subsurface structure at the target level.