# The first field experiment of DAS-VSP using fiber optics deployed inside coiled tubing, onshore Japan

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In CCS projects, it is desirable to monitor whether distribution of injected $CO_2$ is constrained to target formations as planned. Thanks to the recent development, vertical seismic profile (VSP) survey with distributed acoustic sensing (DAS-VSP), which utilizes optical fibers (FO) deployed in a well as permanent multi-channel receivers continuously distributing along the wellbore, has been proofed as a potential complements to reflection seismic survey especially for frequent time-lapse monitoring (e.g., Mateeva et al., 2017).

Among several methods available to deploy FO into observation wells, most of existing field experiments adopted Behind Casing or Along Tubing methods, since these two methods were believed crucial to acquire good quality data at the early stage of DAS-VSP experiment. However, Inside CT methods have some advantages; risk of snapping FO during deployment is low, other monitoring tool such as P/T sensors can be installed simultaneously, and existing wells can be employed as observation wells. While data quality is uncertain, these advantages makes the method worth to be tested. Therefore, INPEX conducted large-scale DAS-VSP field experiment with Inside CT method (Inside CT-DAS-VSP) in August 2017, which primary purpose was to evaluate the quality of Inside CT-DAS-VSP.

A 2D walkaway VSP was selected for this field experiment. DAS-VSP shot gathers were acquired over 70 source locations in total. Two 55K-lbs vibroseis trucks swept simultaneously to emit sufficient vibration energy into the earth. The nominal number of sweeps at each source location was 13. DAS-VSP data were recorded with 1 msec and 4.98 m time and spatial sapling rate, respectively. The observation well, which is one of INPEX’s producing well, has 7”-5-1/2” liner as the final casing, inside which 3-1/2” producing tubing is deployed. The well is deviated around 45 deg. Coupling condition for DAS-VSP was thought to be better in the deviated section. However, there were four steel pipes as maximum between FO and formation at the deviated interval, which might weaken their coupling.

Three examples of near zero-offset DAS-VSP shot gathers are shown in the figure. The gather in left is from only one sweep. We can clearly identify the direct P-wave arrival even with only one sweep, though the ringing-like noise exists in the shallowest portion. We also see strong tube-wave noise, especially after the arrival of direct wave at well head. The shot gather in center is after stacking of 13 sweeps. Because of stacking, signal to noise ratio improves a lot. However, reflections are not yet clear. The gather in right is after tube-wave suppression applied. Data quality further improves, and reflections become apparent. Although data quality was of our biggest concern, we confirmed that not only P-wave direct arrival, but also P-P reflections and P-S converted wave are recorded with acceptable signal to noise ratio even with Inside CT-DAS-VSP, and even at the field where subsurface condition is unfavorable for reflection seismic due to small impedance contrasts. Advanced data processing is necessary for attenuating the dominant tube-wave noise for subsurface imaging. We believe it can be achieved by making the best use of the characteristics of DAS that has extremely denser receiver points than conventional sensors.

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Reference: Mateeva, A., Lopez, J., Chalenski, D., Tatanova, M., Zwartjes, P., Yang, Z., Bakku, S., de Vos, K., and Potters, H., 2017, 4D DAS VSP as a tool for frequent seismic monitoring in deep water: The Leading Edge, 36, 995-1000.

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