

Earthquake Event Monitoring in a Well Using Optical Fiber and DAS Technology

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DAS (Distributed Acoustic Sensing) technology has been used to meet the demands of pipeline monitoring and intrusion detection in Oil & Gas business since 2011. The latest optical fiber sensing technology using differential phase data called “hDVS” (heterodyne Distributed Vibration Sensing), now enables DAS to record seismic signal including VSP (Vertical Seismic Profiling) ¹. The latest tier-3 hDVS system, released in the late 2016, was presented on the JpGU-AGU 2017 ².

In August 2017, the hDVS system was mobilized to Japan as per the request of INPEX for the proof experiments of CT-DAS-VSP operations, using the one of their existing wells in Niigata. Four of optical fibers were deployed into a deviated well with total depth of 4,390m by coiled tubing, and then one of the fibers (single-mode fiber) was connected to the tier-3 hDVS system. This was the world’s first-time field experiment of large scale DAS VSP using fiber optics deployed inside coiled tubing.

In the night time when VSP acquisition was suspended, continuous hDVS recording was performed to aim recording the background noise. This paper presents the feasibility analysis of natural earthquake monitoring by hDVS system with the passive recording mode.

There were two occasions to record DAS background noise continuously; the one was between the night on 23rd of August and the early morning on 24th, and the other was in the early morning on 27th of August (about 12 hours in total). After examining all recorded data, we found a natural earthquake event captured on the data recorded at 19:15 UTC on 26th of August (4:15 JST on 27th). The background noise record around the time is shown in the Figure 1. Note that the continuous recording was performed with the following parameters, Gauge Length: 20 m, Output Spatial Interval: 5 m, and Output Time Interval: 1 msec. The recording length of one file was 30 sec.

Referring to the hypocenter database provided by JMA for all detectable earthquake events in Japan, the following earthquake was identified as the possible candidate of the event observed in the continuous recording period.

(27th of August, 2017 04:15:14.5 Latitude 37°38.9'N Longitude 139°5.1'E 10km depth M2.3 Epicenter location: Central Niigata)

It was observed that the P-wave arrived at the bottom of the well at 4:15:17.8 JST on 27th of August, while the surface section of the fiber detected it at 4:15:18.8 JST. On the other hand, the arrival time of the S-wave was at 4:15:19.9 JST (bottom of the well) and 4:15:22.1 JST (near surface) respectively. Quick comparison between the recorded P-wave and the S-wave arrival time indicates that the apparent velocity of the P-wave is more than twice faster, compared to the velocity of the S-wave.

We also referred continuous seismometer records by NIED (Hi-net). Among the existing 19 monitoring stations in Niigata, the Hi-net data at Muramatsu site, which is the nearest Hi-net station from the wellsite (just about 5km away), is compared with the recorded hDVS data, and it was found that they are matching

well. This was also the first time to record the natural earthquake event using hDVS system in Japan.

It was confirmed that hDVS/DAS system can be used to monitor natural earthquake events while monitoring the reservoir for CCS or other purpose.

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References:

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