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hDVS Distributed Vibration Sensing System Records VSP Using Optical Fibers Cemented in Well Completions

Data efficiently acquired with cemented multimode fiber in one well and with daisy-chained cemented single-mode fiber across all four wells

CHALLENGE

Collect vertical seismic profile (VSP) data in a completed well and compare acquisition using single- and multimode optical fibers permanently cemented behind casing.

SOLUTION

Connect the heterodyne distributed vibration sensing (hDVS) distributed acoustic sensing (DAS) system to the optical fibers to efficiently record seismic data behind casing.

RESULTS

- Confirmed that cemented multimode fiber can be used to acquire VSP data that clearly shows arrivals but is noisier than acquisition with single-mode fiber.
- Obtained good-quality site-wide VSP with simultaneous acquisition from four wells by using one hDVS DAS system interrogator connected to the daisy-chained cemented single-mode fibers in each well.

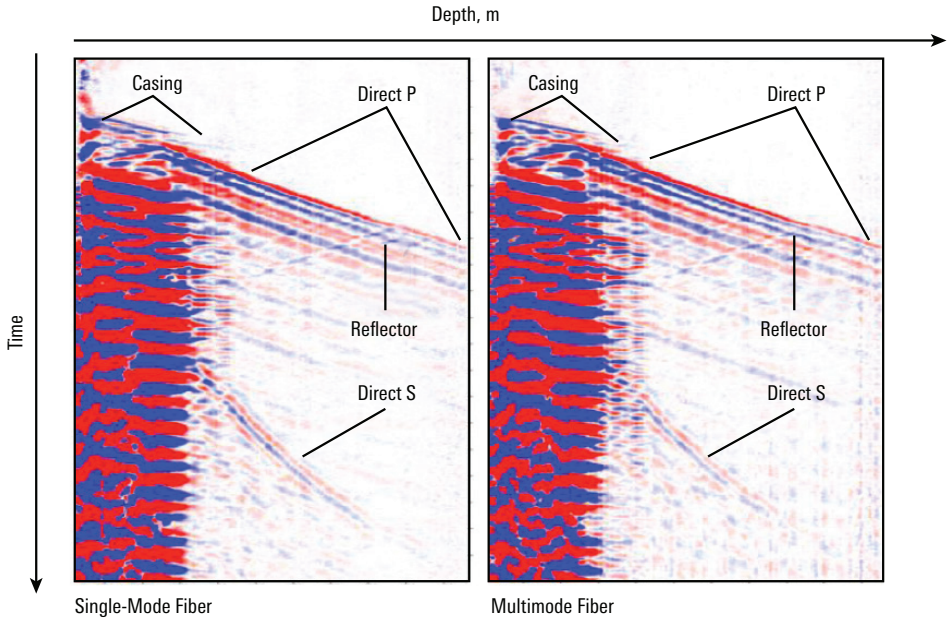
Optical fiber availability for data acquisition

The Ketzin CO_2 pilot capture site is coordinated by the German Research Centre for Geosciences (Deutsches GeoForschungsZentrum, or GFZ) to advance scientific understanding of how to store CO_2 geologically and to research the processes of underground CO_2 injection and migration. The site has one injector well and three monitor wells. For monitoring purposes, the wells have single-mode optical fiber cemented behind the casing, and one of the monitor wells also has cemented multimode optical fiber.

Efficient seismic acquisition using cemented fibers

The hDVS distributed acoustic sensing system brings new efficiency to borehole seismic operations. The system's optical interrogator unit at surface is connected to any optical-fiber cable deployed in a well, from hybrid wireline logging cable to production tubing with fiber installed or optical fiber permanently cemented behind casing. The interrogator records seismic signals, employing the downhole fiber as a vibration sensing device along the full length of the wellbore.

Because the hDVS DAS system makes every logging run or fiber installation an opportunity for seismic data acquisition, it significantly improves the efficiency of borehole seismic operations while lowering the cost. No longer is time required for rigging up and down and deployment of conventional borehole seismic tools because the system is simply connected to the fiber at surface and records seismic data in conjunction with other stationary logging services or on its own. A full well profile is recorded for each shot.



The hDVS DAS system acquired VSPs with a strong reflector and P and S arrivals using either the single-mode and multimode optical fibers, at distances of more than 5 km and less than 1 km, respectively, from the system's interrogator.

Good-quality VSP from either single- or multimode fiber

A truck-mounted accelerated weight-drop source was used as the seismic source, delivering approximately 9,500 J per shot. The data was median stacked using 50 shots, which is equivalent to about 10 minutes of acquisition.

Good-quality VSP data was recorded by the hDVS DAS system in the bottom 70% of the monitoring well with both single- and multimode well fibers cemented behind casing. A strong seismic reflector is present, along with direct shear. Casing arrival is present in the shallow section of the well, which has uncemented double casing, so the optical fibers are not mechanically coupled to the formation.

Although the multimode fiber is closer to the source, the data from it is noisier than that from the single-mode fiber. However, because multimode fiber can be the only option in such permanent installations, the hDVS DAS system can still use it to obtain usable seismic data.

For single-mode fiber acquisition, VSP data was simultaneously acquired at all four wells at the site by daisy-chaining the single-mode fiber across the wells to a single hDVS DAS system interrogator. In this configuration, although the cemented fiber installation in the farthest well was more than 5 km away from the optical interrogator, better-quality data was returned compared with acquisition by the multimode fiber at less than 1 km from the laser source.

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