

Spotlight 4D Monitoring of Steam Injection Using Single Source Single Receiver Technique

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Abstract

Time-lapse reservoir surveillance on land has struggled with data quality (repeatability), surface infrastructure obstacles and operation cost. PDO has tested the cost effective Spotlight 4D technology to monitor steam injection used for enhancing oil recovery (EOR) in a very shallow reservoir. The acquisition is designed to illuminate a spot in the subsurface followed by a processing flow attempting to extract a 4D response which will help understand reservoir behavior in response to the injected steam and improve its injection strategy.

Qarn Alam field is a shallow reservoir (200-400m) consisting of a carbonate anticline. Since 2011, PDO has used steam injection for EOR. The low-cost Spotlight monitoring concept uses a single source and single receiver unlike conventional high-cost 3D surveys. It is performed by selecting a location and acquiring seismic to illuminate a spot in the subsurface. Two acquisitions were conducted, the first one in January 2022 where base and repeatability test data were acquired and the second one in November 2022 where monitor data was acquired. The data were processed by the vendor "Spotlight" and PDO. Acquisition repeatability was challenging due to the surface conditions and processing has suffered from unrepeatable ground roll which masks the target and has proved to be the biggest challenge in the project.

The results showed that the majority of spots have either impossible or very low possibility of 4D detection which makes it not conclusive. That was due to the low signal to noise ratio and the unrepeatable ground roll noise masking the target even with an effective filtering. So, the proposed way forward to escape from the ground roll was by using the diving waves. Diving waves can dive to the required depth without being covered by a high amplitude noise. Therefore, using them in 4D spotlight monitoring technology played a role in enhancing the NRMS values in the area of interest and thus getting better results. This was done by taking a larger offset (1000-3000 m) to catch the signals of shallow targets with the same methodology followed before.

Shallower reservoir and ground roll were the main challenges in this project. In Oman, 4D experience is limited and Spotlight technology was tried first time in PDO. PDO wants to utilize it in steam injection, maturing fields and CCUS. Although 4D signal was very challenging to be detected however, comprehensive leanings have already helped in scoping other 4D projects.