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Time-lapse Surface-Consistent Processing of Buried Receiver Data Using the Virtual Source Method

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ABSTRACT

Land time-lapse seismic monitoring is challenging due to significant variations in source and receiver coupling, daily and seasonal changes in the near-surface, cultural noise, etc. Hence, data need to be enhanced in such a way that reservoir information is preserved and at the same time time-lapse changes only reflect changes at the reservoir. Accurate interpretation of time-lapse data is very important as it leads to robust and efficient decision making process.

Source and receiver variability can be addressed, at least partly, by permanent installation of sources and receivers for the duration of the monitoring period. The repeatability noise due to near-surface variability could be significantly reduced, if sources and receivers were buried under the weathering layer that is subjected to daily and seasonal changes.

In preparation for CO_2 injection monitoring in Saudi Arabian onshore field, the surface-source/buried-receiver strategy was selected for acquisition. During the feasibility study stage a receiver line consisting of 80 sensors was buried at 30m below the surface. The acquired data are redatumed using the Virtual Source method. This is a cross-correlation (interferometric) technique that produces the data that would have been recorded if the sources had been at the locations of the receivers (i.e., using virtual sources). Redatuming reduces the near-surface repeatability noise associated with the layers above the receivers.

To mitigate the non-repeatable noise caused by the source and receiver variations (coupling and seasonal changes) we calculate surface-consistent amplitude components in a novel way using simultaneous, multi-survey strategy and apply them to the data. This processing step replaces other processing steps in the flow that are not 4D compliant. In this way we maintain image quality without affecting the reservoir amplitudes. We test various new ways of time-lapse surface-consistent amplitude correction before and/or after Virtual Source redatuming on synthetic and field time-lapse data. These tests are evaluated on grounds of image quality and repeatability of the stacked sections. The best approach maintains satisfactory repeatability level and preserves image quality.