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Target-Oriented Imaging for Continous Seismic Reservoir Monitoring

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ABSTRACT

Imaging the geometry and property of complex subsurface geology requires sophisticated seismic imaging technologies. A crucial step for such imaging methods is the estimation of wavefields within the earth's interior where no direct observations are available. Standard estimation based on seismic data recorded using surface receivers generally fails to explain how energy propagates in the complex subsurface unless high-resolution seismic velocity models are available prior to imaging. This causes large errors in images and, crucially, in interpretation. The Common Focus Point (CFP) technique had wide applications for seismic data processing. In this abstract, we apply CFP-based technology on multiple field data sets acquired during continuous reservoir monitoring. To minimize the impact of knowing the velocity model we use a simple and robust operator updating strategy without deriving a detailed velocity model. We start with data-driven estimation of the focusing operators at the target using CFP technology. In our implementation, we use the NMO velocity defined at the target horizon to derive the initial operators. The principle of equal-traveltime affirms that the traveltimes of the target reflection event in each CFP gather will be the same as the time-reverse of the respective focusing operator if the kinematics of the operator are correct. According to this principle, the differential time shift (DTS) gathers can be generated by time correlating the focusing operators with their respective CFP gathers. The initial focusing operators are updated iteratively until the principle of equal-traveltime is fulfilled. The stacked image could be derived by stacking of the DTS gathers generated using the final focusing operators. We use CFP technology for the first time to generate efficient and accurate 3D target-oriented images from time-lapse seismic datasets acquired in a CO2 injection project in Saudi Arabia. Applying CFP-based target oriented imaging to time-lapse datasets revealed changes at the reservoir level, which are consistent with the CO2 injection history. We have also observed that the proposed CFP-based imaging technology can provide a powerful and practical tool for improving lithology prediction and 4D signature analysis. This method allowed quick processing of the data and monitoring the CO2 movement within the reservoir without the need to go through full depth imaging of the entire 3D datasets.