4D Seismic Coprocessing Best Practices, Case Studies Offshore, Abu Dhabi, UAE

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Abstract

Time-lapse (4D) seismic processing is routinely used to monitor produced hydrocarbon reservoirs. Seismic reflections are sensitive to formation pressure and fluid content, which means that repeated seismic surveys can theoretically detect pressure changes and fluid substitution inherent to field production. These measurements can help optimize the production strategy and identify areas where hydrocarbons have been bypassed. However, the seismic signal associated with such changes can be minuscule in practice, particularly in heterogeneous carbonate reservoirs. To measure this 4D signal, the seismic acquisition must be repeated as closely as possible, however, Optimum 4D full seismic co-processing could improve seismic repeatability if acquisition repeated geometry is not achievable. Acquisition repeatability is sometimes impossible to achieve in the Middle East due to environmental changes (e.g., dunes, currents, field facilities) but also because the time lapse required to effectively measure production related changes can be so large that the original acquisition technology is either obsolete or uneconomical by the time of the repeat survey. Attempts at permanent (buried) installations for 4D monitoring have been thwarted by high cost and inevitable under-sampling. The seismic data vintages for baseline and monitor surveys must be subjected to co-processing to minimize differences not associated with production. Two case studies from offshore Abu Dhabi. The first seismic survey (Case I) involves two seismic surveys shot 10 years apart with completely different designs. The pre-processing sequences were also very different so the co-processing between the two surveys was partial and only started at 4D binning. The second study (Case II) involves two surveys shot 20 time-lapse, again with vastly different designs. In this case though there was full co-processing between the two surveys. For both studies we ultimately compared a conventional Kirchhoff pre-stack depth migration (KPSDM) with image-based least-squares migration (LSM). Using such diagnostic 4D seismic metric could assess which workflow and algorithm are most likely to ensure an optimum 4D processing sequence. Quantification of the difference is performed through crossploting NRMS versus predictability for full versus partial processing, moreover, for Kirchhoff against LSM seismic imaging. The lower the NRMS value range is significantly reduced when a full co-processing sequence is followed and when LSM migration algorithm is applied. These approaches are therefore recommended to be followed, regardless of acquisition repeatability. Full optimum 4D seismic co-processing could fill up the gap of scarce acquisition repeatability.