

# Insights to 4D Walkaway VSP Reprocessing and Implementation of Advanced Attributes to Monitor CO<sub>2</sub> WAG EOR Pilot in a Carbonate Field Onshore Abu Dhabi

Moza Mohamed<sup>1</sup>, Muhammad Waqas<sup>1</sup>, Jahan Ahmed<sup>1</sup>, Mary Humphries<sup>2</sup>, James Bailey<sup>2</sup>, Aysha Alhamed<sup>1</sup>

<sup>1</sup>ADNOC

<sup>2</sup>VSProwess Ltd.

## Abstract

**Objectives:** Reservoir monitoring is a key initiative for efficient management and development of hydrocarbon reservoirs. Time-lapse feasibility studies are available in literature, however; actual time-lapse seismic surveys are very limited in Abu Dhabi. A time-lapse Walkaway Vertical Seismic Profile (VSP) was acquired as part of the reservoir monitoring plan during a Water Alternating Gas (WAG) Enhanced Oil Recovery (EOR) pilot in an onshore carbonate field in UAE. The purpose of the study is to monitor the injected fluid in the reservoir

**Procedures:** A 4D feasibility study predicted saturation changes >50% after 6 years of water and CO<sub>2</sub> injection resulting in >10% change in reflection amplitude. Time-lapse Pulsed Neutron logs showed saturation changes of about 25% for both water and CO<sub>2</sub> after 3 years of injection. Walkaway VSP survey design was performed but in practice optimum receiver depths could not be achieved due to well tubing resulting in reduced lateral image extent. Three surveys were recently acquired: Baseline survey after 6 months of CO<sub>2</sub> injection, Monitor-1 after 6 months of water injection and Monitor-2 after 3 years of WAG injection.

**Results and Conclusions:** The surveys achieved excellent data quality. There were some small inconsistencies between all the surveys that were revealed and partially resolved during detailed parallel pre-image re-processing of the three datasets. 4D image attribute analysis recovered a subtle time-lapse response. The time-lapse response was compared to the observed CO<sub>2</sub> and water saturation differences and some correlation was observed. Further modeling is required to investigate these small observed differences. Future monitors will take into account lessons from these surveys. It is hoped that this study will provide confidence to operators for deployment of borehole seismic survey technology for future time-lapse monitoring in carbonate reservoirs. Workflows applied in this study will provide a reference point for future geophone or fiber VSP surveys for 4D monitoring. This study also highlights significance of source consistency and quality control that should be performed at wellsite during acquisition.