

Integrated Simultaneous 4D Surface Seismic and 3D VSP to Map Steam Injection in Lower Fars Heavy Oil Reservoir

Chris Koeninger¹, Ahmed Mouaki¹, Dmitri Skorinski¹, Abderrezak Ghida¹, Muhammad El Dayem¹, Xinyuan Li¹, Scott Leaney¹, and Adel El-Emam²

¹Schlumberger, East Ahmadi, Kuwait.

²Kuwait Oil Company, Ahmadi, Kuwait.

ABSTRACT

The Lower Fars heavy oil development project in the Ratqa field of northern Kuwait represents an ambitious initiative by Kuwait Oil Company (KOC) to contribute to Kuwait's overall 2030 strategy of increased production targets. The multi-phase project is planned to produce mainly from the shallow, stacked sandstone Lower Fars reservoir. This will be achieved through extensive data collection, drilling of a large number of wells and execution of pilot studies for enhanced oil recovery (EOR) techniques. A 3D-VSP survey was acquired in a monitor well immediately after steam injection of a nearby injector with the objective of mapping the extend of the steam chamber on the imaged 3D-VSP volume. In addition a 3D surface seismic dataset was acquired before steam injection serving as a time-lapse base survey followed by a monitor survey simultaneously with the 3D-VSP immediately after steam injection. Both base and monitor surveys covered not only the injector closest to the VSP monitor well but all injectors in the pilot area which were at various stages in the CSS cycle. Due to the shallow target the acquisition parameters of the surface seismic were anything but normal with a very dense source and receiver grid and a nominal maximum fold of 968. For the base and monitor surveys one sweep per VP into the surface spread was acquired while for the simultaneous 3D-VSP acquisition during the monitor survey a second sweep into the downhole tool was recorded for all VPs within a 200m circle around the monitor well. The processing of the 4D surface seismic and 3D-VSP data was performed with integration in mind on parameters such as near-surface model estimation, attenuation correction, velocity calibration and anisotropy estimation. Coherent and random noise on the surface seismic data proved to be a main challenge to isolate the steam effects between the base and monitor surveys. 4D attributes were computed after each main processing stage to ensure that each process improved the data without negatively impacting the 4D signal. As expected the VSP data had a much better S/N ratio and resolution and the main effort was spent on wavefield separation and model update/imaging. The talk will illustrate and summarize the efforts and challenges during the acquisition and processing of the 4D surface seismic and 3D-VSP data and conclude with an attempt to answer the objectives of this pilot in terms of effectiveness of steam injection for heavy oil production in this reservoir.