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The Monitoring Role of 4D Seismic in Heterogeneous Carbonate Reservoir Management

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Abstract

One of the main challenges in developing new fields is lack of enough the studied reservoir is located in new explorated field with heterogeneous carbonate reservoir in southwest of Iran with unique reservoir properties. Include low permeability, high H2S content; high initial reservoir pressure with high quality oil with API gravity of 44, the miscible gas injection project was launched in early production period.

The main purpose of the Reservoir management and surveillance is integrating the well flow parameters and further technical data from various sources in order to apply the technical experience and software skills to enhance the production performance. The reservoir management and surveillance procedures are approaches for data acquisition for creative analysis and interpretation of data to exploit the utmost value from each well, level and the whole field.

The main tools to monitor the field as three categories:

i.) the different types of well testing, data acquisition and crude sampling,

ii.) The methodology and softwares that will be utilized to analysis the data and perform the relevant studies to evaluate and optimize the wells and field performance.

iii.) The gas injection monitoring procedures.

Keywords: Reservoir management, 4D Seismic, Monitoring

Introduction

This paper presents how the uncertainties in interpreting the environment of deposition could reduce by production data monitoring and how $D seismic can used for evaluating gas injection process. The main value of 4D seismic is the additional information to constrain or update a model of the reservoir, localization of undrained oil, detailed well planning etc. Knowledge of reservoir connectivity, flow barriers or bypassed hydrocarbons is the kind of information that is expected from 4D data1. Such knowledge helps to optimize reservoir investment decisions. The reservoir models are, in general, constrained by history matching with well production data. As this solution is most often not unique, the combination of 4D seismic (large spatial distribution, but with non-unique interpretation) and well data (single point location, but regarded as accurate) enormously reduces uncertainty. Using this information, subsurface uncertainties are also reduced.

This naturally leads to cost reductions, better well placements and (sometimes drastic) changes in field development plans. Today much of the 4D seismic application is qualitative, or at best semi-quantitative, i.e., the 4D seismic data is used to identify areas of changes in saturation and pressure distributions between seismic survey times. The need to be more quantitative is already here, i.e. to estimate not only what kind of changes but also how large are these changes in saturation and pore pressure2. In the rapid work flows of the future, the quantitative interpretation methods will be an integral part.

The simplest and the most direct method of using time-lapse seismic data is to qualitatively monitor reservoir changes due to production. In this approach, one simply identifies regions in which the amplitude or impedance has changed with time and attributes these changes to changes in saturation, pressure, or temperature. The increase in acoustic impedance ratio between monitor and base survey shows the part of the reservoir which has been drained by injected water.

This type of qualitative use of 4D seismic data has been used for numerous oil and gas fields around the world. For example, 4D seismic has been very useful on the Gullfaks field to identify areas where significant gas saturation changes have occurred and to locate fluid communication paths3. At Meren field in Nigeria, the primary objective of 4D seismic data integration was to identify pathways of injected water, sealing faults, and compartments that may contain bypassed oil4. For the Gannet C oil and gas field in the UK central North sea, 4D data revealed major extensions of reservoir units previously presumed to be absent or thin over much of the reservoir5. As a paradigm shift, 4D seismic monitoring can also be extended to quantify the amount of injected CO2 and any changes that subsequently occur due to leakage or dissolution6. At the North sea Sleipner site, six repeat surveys over 12 years have revealed both an expansion and compaction of the CO2 plume, which is taken from Sando et al. 2. Distribution estimates of the CO2 saturation have been made from 4D seismic data and have increased the understanding of CO2 flow, with reasonable accuracy.

There is a recognized need to combine the skills of geoscientists and engineers to build quantitative reservoir models that incorporate all available reservoir data7. Available reservoir data include conceptual geologic models, seismic, cores, well logs, and production. The challenge is to integrate all these disparate data into a unified, self-consistent reservoir characterization model. The primary objective of history matching (conditioning reservoir models to dynamic data) is to modify a prior model for the reservoir such that the updated model reflects the available production data and the uncertainties in production forecasts are reduced.

The incorporation of 4D seismic data to constrain the reservoir models to update fine-scale geological model, has the potential to improve the overall reservoir characterization. It is a challenging endeavor to perform 4D seismic history matching in the EnKF framework, especially for a real field case with interpreted real 4D seismic data. Our work addresses various aspects of this difficult task. For history matching, we are interested to quantify the performance of the wells, also to match the assimilated seismic data and to estimate the reservoir parameters, e.g., porosity and permeability.

We would like to investigate the sensitivity of different combinations of production and 4D seismic data on EnKF model updating for a realistic synthetic case based on a full field reservoir model from North Sea. In a model updating process or when conditioning a reservoir model to 4D seismic data, the conditioning may be introduced at different levels corresponding to where the mismatch between simulated and measured data is evaluated. An illustration of the different seismic mismatch levelswhich is taken from the work of Skjervheim8.

Field Data Acquisition Activities

For studied field, as per MDP requirements, the following Data Acquisition Approach shall be implemented:

1) Daily Well Performance Monitoring
2) Quarterly Well Testing Campaign Through MPFM
3) Semi Annual Wellhead Deliverability Test Through MPFM
4) New Well Clean Up and Test After Final Completion
5) Annual Well Test for Key Selected Wells and Multi Phase Flow Meter Calibration
6) Any Additional Monitoring Activity Requested by "PMS"

The requested data acquisition will be agreed upon within the “PMS”. The detailed procedures and programs for each of these activities shall be dispatched from the Operator. The analysis of such data shall be reported to the “PMS” as soon as available for further actions.

Conclusions

This paper has presented the applications of 4D seismic and production data monitoring in green field characterization. The study has been performed on oil field in south Iran. We introduced 4D seismic potential and to provide the approaches, procedures for monitoring the fluid-flow changes in a Middle East reservoir during solution-gas-drive oil production from 3 layaer formation.

We provide the approaches, procedures for monitoring by managing data production. Most important Data Acquisition Activities are:

- Daily Well Performance Monitoring
- Quarterly Well Testing Campaign Through MPFM
- Semi Annual Wellhead Deliverability Test Through MPFM
- New Well Clean Up and Test After Final Completion
- Annual Well Test for Key Selected Wells and Multi Phase Flow Meter Calibration
- Any Additional Monitoring Activity Requested by "PMS"

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