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ASSESSING 3D STRUCTURAL UNCERTAINTIES IN RESERVOIR MODELING AND THEIR EFFECTS IN FLUID DYNAMICS

Alejandro Ganzo[1]

1: Baker Hughes a GE Company, alejandro.ganzo@bhge.com

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RESUMEN

Para este estudio, se construyeron dos modelos estructurales 3D para un campo costa afuera altamente fallado, ubicado en la costa occidental de África, basado en la incertidumbre de las fallas sísmicas interpretadas; por lo tanto, se crearon dos modelos de falla y modelos geológicos. Posteriormente, se realizó una comparación volumétrica de fluidos entre los modelos, utilizando como entrada sus respectivos modelos de fluidos. Estos modelos geológicos fueron utilizados luego para el análisis de simulación de flujo del yacimiento donde se investigó el impacto de algunas de las fallas menores en la productividad del campo.

Como primer resultado, presentamos un flujo de trabajo integrado para el modelado de yacimientos estático y dinámico que permite construir rápidamente múltiples escenarios estructurales, y así abordar el efecto de la zonificación estratigráfica, conectividad entre fallas y la compartamentalización de fluidos, llevar a cabo la cuantificación de volúmenes de fluidos y estudiar su dinámica en el yacimiento.

Entre los diferentes resultados obtenidos, las primeras simulaciones mostraron que la producción acumulada de petróleo para el primer escenario es alrededor de un 20% menor, con una presión de yacimiento que disminuye más rápidamente. Por lo tanto, se pudo observar que las fallas menores tienen un efecto significativo en el rendimiento del campo. Adicionalmente, se estudiaron múltiples escenarios de dinámica de fluidos usando diferentes combinaciones de conectividad (sellantes y no sellantes) entre las fallas en el campo.

INTRODUCTION

The main purpose for building a subsurface model is not only for better understanding of the field subsurface but also to define and optimize the field development plan. Depending on the field, the available data, and the application that is used, different companies may have different workflows for building the subsurface model. In most cases, the main input data for building a 3D geological model are wells data and seismic data, which from both data an interpretation and/or extra calculation need to be done.

Furthermore, dynamic modeling permits to identify the behavior of the fluids within the reservoir at operational conditions and the impact of the reservoir structure and properties in the fluids flow. The objective of dynamic modeling is to forecast field production, estimate recovery and create/try different field development scenarios.

In this study, two different 3D structural models of the studied field were built based on the uncertainty of the interpreted seismic faults; hence two fault models and geological models were created. Later, a fluid volumetrics comparisoň was taken between the models using as input their respective fluid models. These geological models were taken for flow simulation analysis where the impact of flow across some of the minor faults in the field productivity was investigated.

An integrated static and dynamic reservoir modeling workflow is presented to quickly build multiple 3D structure scenarios, address the effect of different stratigraphic zonation, different fault connectivity, and/or different fluid compartmentalization, carry on fluids volumes quantification and study their dynamics in the porous media.

THEORY AND METHOD

For this study the workflow used to build the geological models is presented in Figure 1.Building a 3D structural model is one of main steps in reservoir modeling and it includes building stratigraphic and fault models.

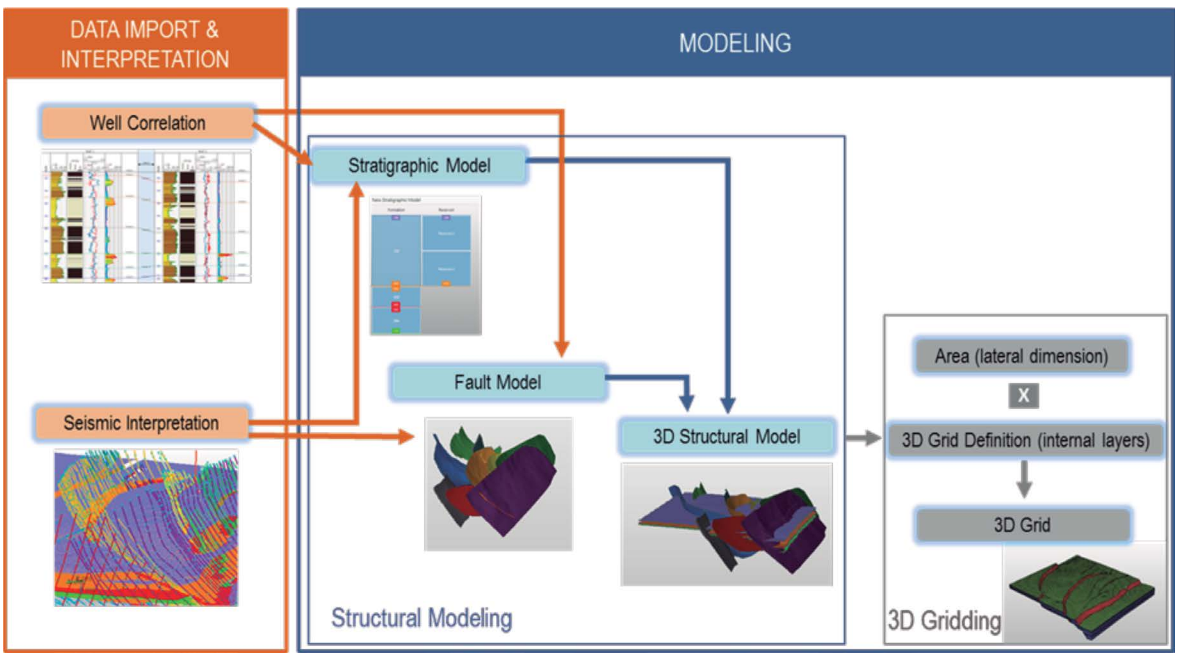

Figure 1. Structural Modelling Workflow

Stratigraphic Model

The inputs for building the stratigraphic models can be the well markers and the seismic horizons. This model is used to define the construction sequence during the creation of the 3D grid model. The principle of the stratigraphic model is comparable to a general stratigraphic column where zone definition is according to hierarchical levels. The levels can be divided into different details, known as group, formation, unit, zone, etc.

Fault Model

The fault interpretation, either as fault stick or tri-meshes fault surface can be used as input for the fault model. Fault modeling covers the process of assigning input faults into a fault model, generating the connectivity between faults, and creating the fault intersection, so that a faulted 3D grid can be created.

3D Structure Model

This is built based on the combination of a stratigraphic model and a fault model. This is a process of creating a water tight structural framework, consisting of horizons and faults. Furthermore, depend on the level that you choose for the stratigraphic model, the horizons of the 3D structure will be built based on this level.

Multiple scenarios can be implemented in the stratigraphic model, fault model and the combination of both (3D structure model). Therefore different possibilities of structural framework based on a different stratigraphy and/or fault can be built. This structural modeling approach makes it possible to create and compare multiple geological models. It is important in case of fields with much uncertainty in the geological structure and/or with a complex structure.

RESULTS

This study was carried for a highly-faulted offshore field at the West Africa coast. The field is an elongated roll-over anticline with its hydrocarbon bearing sandsoccurring in multi-stacked reservoir sequences. This field is densely faulted by a conjugate system ofsynthetic and antithetic faults with comparatively small sand thicknesses and sealing shales.

The 3D seismic reflectivity volumes used in this study cover the uppermost 3 km of an around 100 km^2 large survey area, where several horizons and faults have been interpreted. The seismic shows asyn-sedimentary growth fault that extends laterally over several kilometers. These faults subdivide thearea of interest into four major blocks that are completely separated from each other. Within fault block 1, there are many growth faults in the crestal collapse area.

In this study two 3D geological models (both static and dynamic) have been created. The first 3Dgeological model only incorporates the major faults which bounds the four major blocks. The secondmodel also includes several minor faults in the crestal collapse zone.Each of these represents a geologically feasible scenario.

Even though this field consists ofmultiple stacked reservoirs, the reservoir simulations were carried out only for one reservoir zone, toquickly analyze the impact of flow across some of the minor faults in the field. Furthermore, several wells and wireline logs are available in three fault blocks, which are used to populate the facies and petrophysical properties in the whole 3D grid. For the two 3D grid models, all other data, methods and parameters used for further processing in the static and the dynamic modeling are the same. This includes the number of wells, logs, layering, cell sizes, and flow simulation constrains.

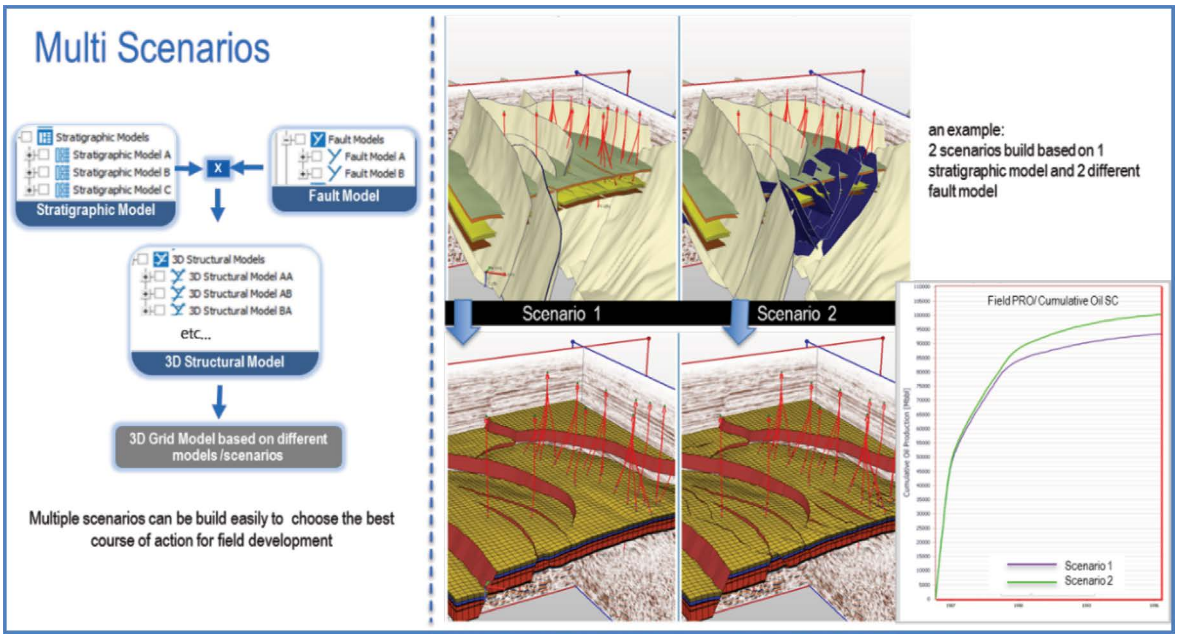

Figure 2. Multi Structural Scenarios analysis for flow dynamics

In the first scenario, the structure model consisted of 5 horizons and 9 main faults in the field. For the second scenario, several minor faults were inserted into the model. Both models were compared in terms of fluids content and then the effect on fluid flow and field performance were compared using JewelSuite CMG IMEX connector.

Among the different results obtained, the first simulation runs showed that the cumulative oil production for the first scenario is around 20% less with a more rapidly dropping reservoir pressure “(Figure2)”. Hence, the minor faults do have a significant effect on the field performance. Multiple scenarios were studied using different combinations of sealing and no-sealing faults.

CONCLUSIONS

This article presents the JewelSuite Subsurface Modeling integrated reservoir modeling workflow applied to a real field case. With its new generation gridding technology, multiple scenarios can be easily and accurately created to quickly address the effect of different stratigraphic zonation, different fault connectivity, and/or different fluid compartmentalization.

The possibility to have multiple scenarios for structure modeling is important for fields with uncertainty in the geological structure and/or with a complex structure.

For this study, it was observed that the modeling of the faults in the crestal zone of the field is very important to the outcome of the reservoir simulation analysis, which can help to better carry history matching and field development optimization.

Future studies can be carried including variations in the stratigraphy (multiple stratigraphic models/zonation) or adding more fluid compartmentalization scenarios.

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