Techniques for integrating seismic, outcrop and well data in geomodeling of deepwater systems: example from Offshore Niger Delta, Nigeria

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Maturing hydrocarbon discoveries and re-development of existing assets requires a detailed assessment of the reservoir potential, including the uncertainty analysis. Deliverables from such assessment includes in-place hydrocarbon estimates, well placement including type and number, well/reservoir performance, assessment of recovery mechanisms and uncertainty analysis and management. Development projects in deepwater are predicated on high rate/high recovery producers supported by water injection, due to high development cost. Typically, well costs may account for a third of the project budget and so well optimisation is a major part of any study. A robust development planning will therefore depends to a large extent on the construction of geological models that more accurately represents the subsurface in terms of the vertical and lateral variation in reservoir geometry, architecture and facies associations as well as help to characterise and manage key uncertainties.

3-D geomodels have historically been based primarily on well data, however, advances in the field of geophysics-seismic inversion, seismic geomorphology and seismic sedimentology have allowed geomodelers to integrate seismic data with well and outcrop analogue data to build better 3-D models. In this paper, a workflow for integrating seismic data, outcrop and well data at the appropriate scale into a 3-D geomodel for a deepwater meandering channel complex from offshore Niger Delta will be presented. The workflow is premised on detailed interpretation of the seismic data (using seismic geomorphology and seismic sedimentology principles) conditioned with well and outcrop data. This interpretation forms the basis for understanding and visualizing gross reservoir geometry, architecture, heterogeneities and facies distribution. The interpretation also allows for an assessment of reservoir connectivity and channel stacking patterns which is critical to development planning of deepwater systems to be made.

The first step in the workflow is to construct a deterministic model framework that represents the gross reservoir geometry using information derived from the seismic and outcrop data by means of the object-based modeling approach. This is then followed by sub-seismic modeling of channel bodies and facies in a manner that accurately reflects their lateral location and vertical stacking patterns using data derived from seismic, well and outcrop data. Within the geomodel, this is also achieved with the object-based modeling approach. Object-based modeling addresses fairly well the inherent characteristics of channel systems when compared to a purely stochastic approach and allows for a better handling of reservoir stacking and connectivity. The final step is a stochastic modeling of the reservoir properties – porosity, permeability, net-to-gross, netpay or netsand and water saturation within well-constrained bodies and geometries using well and seismic data. The resulting 3-D model is seismically and geologically well-constrained and conditioned, allowing for accurate assessment of key reservoir uncertainties. It is also an invaluable hydrocarbon development planning tool allowing for better decisions on reservoir development and management.

This approach and methodology although developed for deepwater systems, is also directly applicable to fluvial systems.