Integrated Geological Process Modeling Solutions for Derisking Exploration: Stratigraphic, Organic Matter and Early Diagenetic Forward Modeling

Didier Granjeon, Youri Hamon, Benoit Chauveau
IFP Energies Nouvelles

9.29.2020 - 10.1.2020 – AAPG Annual Convention and Exhibition 2020, Online/Virtual

Abstract

Exploration of frontier areas such as the pre-salt Aptian are back to the present. These exploratory plays have yielded large petroleum discoveries along the South Atlantic margins but are still in their infancy. Accurate sedimentary and diagenetic facies models are mandatory to reduce exploration and development risks but sedimentary systems are usually poorly imaged on seismic data in such frontier areas, and geological scenarios are subjects of lively debates. For example, different geological scenarios have been proposed to characterize the Barra Velha Formation, from microbial and stromatolites carbonate buildups, to travertine shrubs induced by hydrothermal fluid influx along major faults, or shallow evaporitic salt crusts. Thanks to the artificial intelligence and data analytics, geological and geophysical processes could be automated and could provide more and more accurate images of the subsurface geology. But despite their reservoir scale increasing potentialities, these approaches are not yet fully applicable to assess plays in frontier areas where only few data are available. The understanding of sedimentary facies and source rock distribution is thus a crucial question to tackle, whatever the scale investigated. To address this exploration challenge, we propose an integrated workflow using advanced geological process modeling solutions, able to simulate (1) stratigraphic processes, (2) organic matter production, degradation and preservation, and (3) carbonate early diagenesis. This forward simulation reconstructs stratigraphy and facies architecture through

geological time at basin or appraisal scale while honoring core, well logs and seismic data. Accounting for basin deformation, eustasy and sediment supply, DionisosFlow simulates sediment erosion, transport and deposition as well as local carbonate production. Nutrient concentration are then taken into account to control marine organic matter primary production, while degradation along the sea water column and sea floor depends on oxygen supply and consumption. Finally, the tight coupling of stratigraphic, hydrological and early diagenetic models, allows us to estimate the impact of early diagenesis processes on sedimentary rock properties (mineralogy, porosity), and on source rock characterization (kerogen type, HI/OI, etc.). This workflow was tested on a pre-salt carbonate reservoir along the Brazilian margin to illustrate its potential contribution to the derisking of pre-salt carbonate exploration. Each geological scenario is evaluated through a geological process modeling workflow, integrating stratigraphic, organic matter and early diagenesis processes. This evaluation leads to a scenario ranking, and to the 4D geologically-consistent digital basin models required by basin modeling workflows.