

Sensitivity and Risk Analysis Applied to 3D Petroleum & Basin Modeling Simulations. A Case from the Pre-salt Province in the Offshore Brazilian Basins

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ABSTRACT

The pre-salt reservoirs of the Santos and Campos basins, offshore of the Brazilian coast, accounted for very large discoveries for the last decade. Since the more attractive structures have been drilled first the exploration teams are now targeting more risky prospects. The exploration strategy has to be adapted to such challenges and risk analysis is a key tool to better constrain the geological and financial risk associated to these expensive drillings.

Sensitivity and risk analysis using experimental design and response surface methodology (RSM) are currently being used by Repsol to assess future exploration potential in these basins. The following case illustrates the prospect ranking established from 3D basin modeling simulations generated from experimental design. Liquid saturation was chosen as the output that best reflects the prospectivity of the studied area. Actually it considers the risk on 1/ source-rock richness, 2/ source-rock maturity, 3/hydrocarbon charge and 4/ seal and preservation.

Results of the sensitivity analysis, for the studied area, point to the maturity (heat flow and/or erosion) and the migration efficiency as the most impactful parameters, whereas, the source-rock kinetics is not a sensitive parameter to the hydrocarbon generation. The interpretation of these results is that although the selected kinetics represent up to 15°C difference in the hydrocarbon generation curves, this shift is not sufficient enough to significantly affect the whole process of generation, expulsion and migration and thus the hydrocarbon saturation at the prospect location. This is true for the study area, due to the high prospect area concentration and short average distance between source and reservoir.

Risk analysis is done using normal, triangular or binomial distribution for the most impactful parameters. Final results show a relatively narrow variation between P90 and P10 percentiles interpreted as a low sensitivity of the prospects to the input data. This is due to the reasonable to good knowledge of the studied petroleum system elements, as well as, the constraints on the maturity affecting parameters that must stay realistic. Although all prospects present good characteristics the P50 value of the liquid saturation has been used to establish a prospect ranking list.

As the studied output (hydrocarbon saturation) represents the prospectivity, fairly well, (only reservoir aspects are not especially considered) this ranking list represents an alternate method to classical risk analysis which is only based on normal distribution and Monte Carlo simulation. Hydrocarbon saturation distributions, such as presented in this study, can also be seen as a pseudo-Pg (probability of geological success) easily shared by exploration geologists, portfolios and management.