Coupled Forward Stratigraphic and Basin Modeling for Unconventional Petroleum System Analysis

Keyu Liu[1,2], Xiu Huang[1], and Jianliang Liu[1]

[1]Research Institute of Petroleum Exploration and Development, PetroChina, Beijing 100083, China
[2]Curtin University of Technology, Bentley, WA 6102, Australia
[3]Jilin University, Changchun, Jilin Province, 130012 , China

ABSTRACT

Petroleum system analysis and basin modelling have become an integral part of modern petroleum exploration. However, with the emerging unconventional petroleum exploration, the traditional source to trap model becomes vague spatially, as the source and reservoir may intermingle within the same stratigraphic unit. The only control on the spatial distribution of sources and reservoirs are the sedimentary facies or micro-facies. Modelling the depositional heterogeneities, thus, becomes critical for more accurately characterized unconventional petroleum systems within a basin.

The currently available basin modelling programs are not created to deal with such fine-scale characterization of heterogeneities within a sedimentary system, as most of them are using more or less “layer cake” models to approximate stratigraphic sedimentary layers in their geological model construction. To address such a challenge, and to model both conventional and unconventional petroleum systems holistically in a single simulation, we proposed to couple forward stratigraphic modeling (FSM) with basin modeling, whereby the former provides a detailed 3D sedimentary facies volume with fine heterogeneities effectively captured as input for the latter. The forward stratigraphic model we chose in our study is a hydrodynamic-based program called SEDSIM. The SEDSIM program can model clastic, carbonate and organic deposition with spatial resolutions from cm to m vertically and 100s of m to 100s of km horizontally.

In the SFM (SEDSIM), the workflow starts with a conceptual geological or sedimentary model (Step 1), which may be based on geological understanding of the target area and stratigraphic interval from regional analysis and/or modern analogue study. At this step the objectives of the simulation is set. A set of input parameters or parameter sets are then collated and screened to the initial model construction (Step 2). The model was then run for the target time interval to generate a preliminary model (Step 3). The simulation outputs are then compared with the known geological observations, records, spatial and temporal data such as seismic, well log and core data. If the discrepancy between the simulation results and the real geological data is beyond the expectations, then Steps 1-3 will need to be repeated iteratively until the modeled outputs and the real geological data converge to a satisfactory level. The modelling process itself is also a process to test various scenarios, remove uncertainties and understand the geological model. The output of the modeling is a 3D volume of lithology with sedimentary facies (e.g. paleo-water depth and sorting) tagged, which can be used directly to import to a basin modelling program and/or to constrain the spatial heterogeneities.