Capturing uncertainty in a carbonate field with dense well control: example from western offshore basin India

Sourav Saha, Mohit Khanna, Nazneen Sultana, Tanmoy Roy and Anurag Grover

BG Exploration and Production India Limited, BG House, Lake Boulevard, Hiranandani Business Park, Powai, Mumbai – 400 076, India

Panna Field is situated ~100 kilometers northwest of Mumbai city and 50 kilometers east of the giant Bombay High Field in Bombay offshore basin. The principal hydrocarbon bearing reservoir zones in Panna Field are Middle Eocene Bassein-B Upper limestone and Early Oligocene Bassein-A limestone. Bassein limestones (BU and A) are deposited in a distally steepened ramp in an open shelf setting. It is a broad, low relief, anticlinal trap with associated fractures and faults. Bassein-BU reservoir is ~50 m thick with conspicuous lateral continuity of vuggy porous limestone. Bassein-A is ~45-50 m thick and comprises of tight shaly limestone at base which is overlain by moderate quality limestones. The oil column is ~ 20 meters thick with gas-oil-contact (GOC) at 1737 m TVDS and free-water-level (FWL) at 1762 m TVDSS (oil-water-contact -1757 m TVDSS). To capture reservoir heterogeneity and flow units of the reservoirs zone, Bassein BU and A zones are subdivided into smaller fine scale reservoir zones based on petrophysical character. Top of BU is a karstified surface formed during Eocene-Oligocene sea level fall coinciding with the global sea level fall.

Full field geocellular model is built in IRAP RMS (9.0.7) using all available well data (~250 wells) and depth structures. A detailed petrophysical modeling is carried out within the above mentioned reservoir zones. Total porosity (PHIT), shale volumes (VSHALE) and effective porosity (PHIE) are modeled stochastically to capture heterogeneity in reservoir zones. Saturation and permeability modeling are modelled using relationship with porosity and height above FWL. Net to gross (NTG) is calculated as a discrete variable using PHIE (5 pu) and VSHALE (30%) cutoff. The high resolution geocellular model was with 5878524 (~5.8 million) cells was upscaled to 3491280 (~3.5 million) cells.

Static uncertainty has been performed on GRV, STOOIP and GIIP using simulation gaussion algorithm inside RMS on the history matched geocellular model. Structure (GRV), PHIT, VSHALE, PHIE, distribution of these parameters in terms of variograms, initial water saturation and OWC are used for uncertainty analysis. A total of 50 structural realizations are created using a standard deviation around the base case structural interpretation. These structural models were then used as inputs to capture low case and base case petrophysical and hydrocarbon saturation.

Minimum, maximum and mean are calculated from the uncertainty analysis in terms of STOOIP and GIIP together with percentile distributions. The overall uncertainty is relatively low and STOOIP and GIIP are showing vary narrow range in their distribution. The mean of the total STOOIP from the uncertainty analysis is 2% higher than the base case. Geometric connectivity on permeability of all models for two zones (BU and A zones) is calculated to understand its effect on the inplace hydrocarbon volumes. Considering the STOOIP, GIIP along with the geometric connectivity the P10 and P90 models are selected for further history match. The dominant parameters that contribute to the uncertainty in STOOIP and GIIP are oil/gas saturation together with the structure in the respective zones.