A Robust Approach Towards Safe and Cost Effective Drilling in High Pressure Formations

Yusuf Pamukcu¹, Philippe Nivlet¹, Saad Sasy¹, and Fabio Ravanelli¹

¹SAUDI ARAMCO, DHAHRAN, Saudi Arabia.

ABSTRACT

Formation overpressures often result in problems during drilling operations. High mud weights necessary to control the formation pressure impede drilling progress through low rate of penetration (ROP). Non-productive days, stuck pipe and, in some cases loss of wellbore, add operational cost and delays to the field development program. Therefore, accurate pre-drilling pore pressure prediction is crucial for over-pressured formations. The focus on this paper is a carbonate formation which varies in thickness and consists of two main lithology packages that include, (1) a lower, mainly tight, dolomite with thin shale beds and anhydrite and, (2) an upper predominantly anhydrite lithology. Explicit well data (e.g. mud weight) can be utilized to map overpressure areas via a deterministic approach. Deterministic mapping has reasonably high confidence when constrained with sufficient well data. On the other hand, with increasing distance from well control, confidence is reduced. Hence a major limitation of the well data map is the lack of predictability in undrilled areas. In order to improve predictability, a probabilistic approach utilizing Sequential Indicator Simulation (SIS) was employed. A set of multiple geological realizations built by sampling 80% of the drilling data was used to construct the risk-model. The confidence in these realizations was estimated by means of blind-tests using the remaining twenty percent of the data. The highest-rank models exhibits a reasonable match with the pattern of overpressure occurrence. Finally, seismic data has been utilized to predict seismic over-pressure map by classification of seismic waveform calibrated to well information. This map has been used as a spatial trend to improve inter-well pore pressure prediction. This integrated modeling approach substantially improved the predictability of high pressure zones from 15% (deterministic approach) to currently 70% (probabilistic approach followed in this work).