Pore Pressure Prediction While Drilling: 3D Earth Model in the Gulf of Mexico

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ABSTRACT

Subsalt Gulf of Mexico deep water wells routinely cost in excess of $100 million. The capability of a reliable pore pressure prediction can translate to considerable savings in terms of drilling costs. Traditional methods used to determine pore pressure are derived either from logs (Eaton's method, Bower's, etc.) and seismic (calibrated seismic velocities, acoustic impedance, etc.). However no one method is commonly accepted as better than another, therefore the capability of integrating all methods in a full 3D Earth Model, coupled to a three component stress behavior, can provide a higher degree of confidence for pore pressure prediction.

Pore Pressure prediction using a 3D Earth Model for sub-salt Deep Water GOM projects requires integrating seismic attributes, geological information, well log data, drilling information and drilling events. Recent developments allow coupling of classical pore pressure models with 3D stress models especially for fracture gradient prediction. This also allows for a correct understanding of the significant 3D effects in the vicinity of salt.

The first step of the work flow is to create and calibrate a regional model based on a set of regional maps with the main goal to provide the regional context. Accounting for possible regional faults, pressure relief points, mini basins distribution and a full 3D salt restoration through time able to provide the salt geometries related to salt withdrawal.

The second step is to create an AOI model using high resolution structural and facies maps based on specific seismic character converted to net to gross. This refined model will then be used for pore pressure prediction at the prospect scale. The smaller AOI model, albeit at very high resolution, allowed a model to be run overnight so that pore pressure could be predicted ahead of the bit. Furthermore LOT, LWD formation pressures data and drilling events collected while drilling provided a very good calibration for the model.

A common element to both regional and AOI models is the capability to use a basin modeling software that allows full stress tensor and pressure analysis in three dimensions.

Finally, the predicted pore pressure and fracture gradient allows the drilling engineer to optimize well performance and reduce drilling costs. The integration of all the different disciplines and expertise through a 3D basin model resulted in the well to be drilled under budget and most important safely.