CHALLENGE
Improve the accuracy and timeliness of pore pressure prediction to support drilling efficiency and safety.

SOLUTION
Use PetroMod* petroleum systems modeling software in conjunction with support from the Schlumberger Exploration Hub to integrate all data in a calibrated 3D model for predicting pore pressure with greater resolution.

RESULTS
Accurately predicted pore pressure and fracture gradient for optimizing well performance while reducing cost and risk.

Navigating potential drilling hazards
Murphy Oil Corporation’s deepwater prospect well was planned in the Mississippi Canyon in the vicinity of salt diapirs, which induce smaller sub-basins. The drilling targets were disconnected Miocene turbidite sand reservoirs with varying overpressures, depending on their geometry and pinchout toward the salt.

Isolated overpressured sands are often dangerous to drill. A number of techniques exist for predicting pore pressure from well logs to seismic data. However, these stand-alone techniques, such as seismic pore pressure prediction and using data from offset wells, have only limited resolution or are not representative when disconnected target sands are present. Integrating these techniques in a full 3D earth model and modeling all geological processes responsible for increasing pressure through geological time can provide higher confidence in pore pressure prediction.

Murphy Oil recognized the need for an integrated geological approach to basin modeling to identify potential hazards during drilling. The model would require real-time updating capability for new information acquired while drilling.

Building a calibrated, high-resolution model in PetroMod software for pore pressure prediction
Schlumberger proposed building a 3D earth model in PetroMod petroleum systems modeling software to fully integrate seismic attributes, geological information, well log data, and drilling information. Recent PetroMod software developments enable coupling classic pore pressure models with 3D stress models, especially for fracture gradient prediction. This in turn supports a more accurate understanding of significant 3D effects—such as compaction history and pressure development coupled to three-component stress behavior—through geological time in the vicinity of salt.

In high-resolution petroleum systems modeling, the seismic attributes drive the facies.
CASE STUDY: Murphy Oil reduces drilling risk with pore pressure from PetroMod software, Gulf of Mexico

A two-step workflow was developed, with the models built by the Murphy Oil team in Houston and supported locally by Schlumberger experts in collaboration with the Schlumberger Exploration Hub in Aachen, Germany.

The first step was identifying the layers responsible for overpressure and modifying their lithological composition to match calibration data from offset wells. This regional pore pressure model also accounted for regional faults, pressure relief points, sub-basin distribution, and salt deformation through time.

In the second step, a higher-resolution geological model was built over a focused area of interest by using high-resolution structural maps and facies maps based on seismic character. The high-resolution model for the area of interest could be run in under 12 hours, powered by recent improvements in PetroMod software’s simulator speed. This speed enabled completing full model runs overnight to provide pore pressure prediction results ahead of the bit for morning meetings.

The model was calibrated daily using leakoff test results, logging-while-drilling formation pressure data, and information on drilling events.

Accurately predicting pore pressure ahead of the bit

The workflow in PetroMod software enabled integrating all available data into the geological model for daily update and simulation. The results from the simulations provided useful information on whether to follow the original drilling plan or modify it to avoid drilling hazards. The pore pressure was consistently accurately predicted for the well ahead of the bit and then the model’s performance refined by calibration to the measured data.

The drilling engineer used the predicted pore pressure and fracture gradient to optimize well performance and thus reduce drilling costs and risk in the expensive, hazardous subsalt drilling environment of the Gulf of Mexico. The well was successfully drilled under budget and without safety incidents.