

# Pore Pressure Prediction

**Accurate prediction of pore pressures and fracture gradients has become almost essential to drilling deep wells with higher-than-normal pore pressures.**



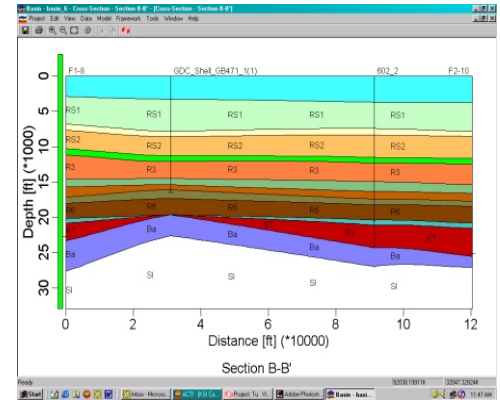
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Costs and drilling problems can be reduced substantially by recognizing abnormally high pore pressures early. The accurate determination of fracture gradients defines the need for protective casing that must be placed on total annulus pressures during drilling.

Every method used to recognize or predict changes in pore pressure is based on formation compaction or the lack of it. Compaction occurs primarily in shales; hence, most prediction methods are based on what happens when drilling or logging shale sections, and shale becomes denser as depth increases. If this does not happen, suspect abnormally high pore pressures.

Pore pressure transmission also can be described as the transmission of mud overbalance pressure by penetration of the mud filtrate into the rock micropores and fractures. This transmission of mud overbalance pressure to the rock weakens the rock matrix, but more importantly, effectively removes the differential pressure between the mud and the rock, causing hole instability.

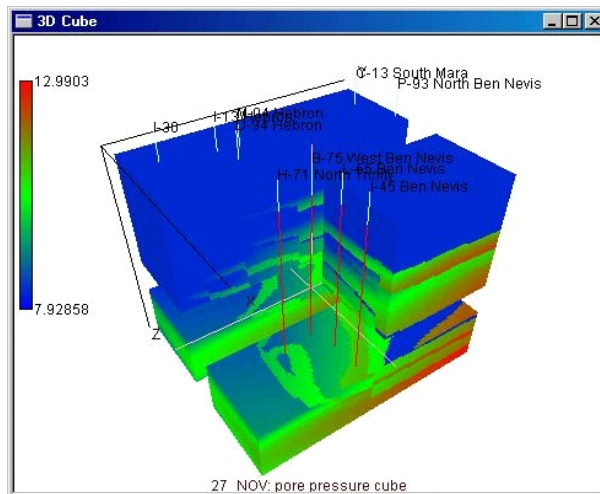
Recognizing changes in pore pressure while drilling is vital so that mud weight can be altered before problems develop. Decreases in pore pressure may signal lower fracture gradients and a high vulnerability to underground blowout. Increases in pore pressure, if not contained by quick increases in mud weight, may result in difficult-to-control well kicks and subsequent blowouts.



BP has developed new technologies to monitor the wellbore pressure in real-time. The operator can determine the pore pressure and fracture gradient in real time from logging-while-drilling (LWD) measurements and managing the wellbore pressures between these limits.

Two recent deepwater Gulf of Mexico wells have benefited from real-time wellbore pressure management at the wellsite. The advantages of having a good handle on the pore pressure and fracture gradient while drilling in deepwater include:

- Safety;
- Avoiding time lost and cost due to kicks and losses;
- Pushing casing seats as deep as possible to eliminate additional casing or liner strings;
- Improved average rate of penetration by avoiding unnecessary flow and bottoms-up checks; and
- Increased chance of reaching deep exploration targets.



## Pore Pressure Monitoring

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## Real-time pore pressure

Wellbore pressure management is reliant on an accurate determination of pore pressure. BP, during normal drilling operations, provides predrill pore pressure predictions based on analysis of seismic velocities, offset well data and basin modeling. However, predrill estimates are, by their nature, uncertain. Limitations include:

-  Low resolution of seismic interval velocities;
-  Questionable accuracy of depth of events ahead of the bit; and
-  Uncertainty in the seismic velocity to pressure transformation.

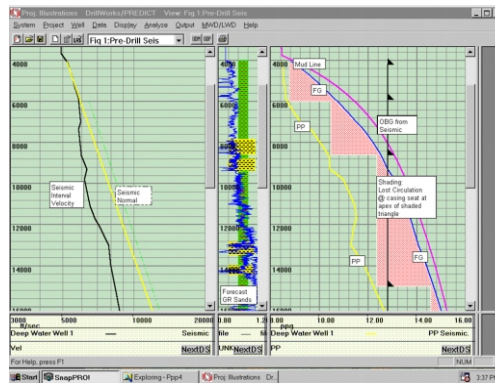
The inherent uncertainties in predrill predictions can be addressed by interpreting LWD logs in real time. The sonic and Resistivity measurements can be used (together with a gamma ray) to perform a pore pressure analysis.

Essentially, this means the drilling team can monitor the pore pressure right behind the bit 24 hours a day. Using this technology, the drilling team can gain more value from LWD measurements, and it can use the data to support important drilling decisions.

In situations where the pore pressure model shows a significant change, the interpretation skills of the onshore experts can be called upon. Collaboration between the onsite engineer and the onshore pore pressure specialist is vital.

## Real-time fracture gradient

The upper limit to the wellbore pressure management window generally receives less attention than the pore pressure but is equally important. Pore pressure is a significant input to the fracture-gradient calculation. As pore pressure is being computed in real time, so too is the fracture gradient. The onsite engineer computes sand and shale fracturing gradients. Shale fracture gradients can be calibrated to leak-off pressures, which are measured accurately with downhole pressure Gauges. In addition, recent work with multiple depth of investigation Resistivity tools has started to reveal a mass of information about fracturing and fluid loss in the wellbore in both sands and shales. This is essential information the onsite engineer is well positioned to make good use of to calibrate fracture gradient models.



## Additional monitoring

In addition to the LWD and MWD measurements, the onsite engineer integrates all other indicators of pressure. These tend to be indicators mud-loggers traditionally have monitored, such as background and connection gas, cuttings and cavings, rate of penetration and torque, mud losses and gains. Onsite engineers work closely with the mud-loggers, shaker hands, drillers, the drilling engineer and the company man to obtain as much pressure-related information as possible. Armed with this information, the engineer acts as a focal point for information and decision support, which in turn can provide good wellbore pressure management.



*Experts in Pore Pressure Engineering at work. Datalog prides itself on the experience and professionalism of its people.*

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