

Pore Pressure Estimation and Calibration in Gas Shale Reservoir

Xin Chen¹

¹Schlumberger

Abstract

Overpressure mechanism is studied in Silurian Longmaxi shale gas reservoir in the Sichuan Basin and Bower's theory is applied in the implementation of 3D pore pressure model. The model is then calibrated with drilling mud weight by referring to total gas detection from all drilled wells, and is widely used in 3D MEM study, drilling safety analysis, and mud weight optimization.

In order to build an accurate pore pressure estimation model, steps below are adopted in the whole study:

- Creation of 3D sonic velocity model, which supplies the crucial input for pore pressure model creation. Lacking of high precision of seismic data, velocities from both vertical wells and horizontal wells have been implemented to control 3D velocity distribution. Considering the laminated effect of shale, correction of measured velocity from horizontal wells is required to make it verticalization. Then a 3D velocity model is built by including corrected velocities from all pilot wells and horizontal wells. The 3D model has then been calibrated by the new logging data.
- Definition of pore pressure model. The mechanism of overpressure in the formation is mainly due to repressurization generated from hydrocarbons. Therefore, Bower's theory is adopted to represent this typical Type-II overpressure, and 3D pore pressure model is built by using Bower's unloading equation. Also, ACA (after closure analysis) data from DataFrac is provided for pore pressure model validation.
- Calibration with drilling mud weight by referring to total gas detection from all drilled wells. When underbalanced or near-balanced conditions of mud pressure relative to formation pore pressure exist, typical gas responses, e.g. gas kick and connection gas, will be able to be observed, which indicates pore pressure response under certain mud weight. By calibrating with all drilled wells, a reliable pore pressure model is determined and is used for further engineering usage.

Together with 3D MEM (mechanical earth model) result, pore pressure is implemented into drilling safety study. Wellbore stabilities are simulated and safe mud windows are supplied for planned and drilling wells. Based on the study, recommended mud weight was proposed to client, and drilling issues were controlled well with optimized drilling plans.