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Pore Pressure Estimation – A Drillers Point of View and Application to Basin Models

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ABSTRACT

Pore pressure estimation while drilling is extremely important. Accurate estimation not only effects the safety of the drilling operation. It also effects the time and cost of drilling as well as the condition of the formation for testing and production. In cases of extreme overestimation the mud pressure may destroy seal integrity. Accurate constraint on pore pressure is an important constraint on basin modeling.

In drilling we attempt to constrain estimates of mud weight while drilling, to within at least one half a pound of actual pore pressure and in many cases we are able to be within one eight of a pound. An extensive study of pore pressure estimation methodology was conducted and reported in DEA 119.

Many techniques were tested, including neural network and dimensional analysis techniques. The most accurate methodology are based on Terzaghi's compaction model. This involves an estimation of overburden and porosity as a function of depth from velocity, density, or resistivity logs. Using measured pore and facture pressures in sands a calibration curve is developed and used to estimate pore pressure in the shales. The technique can be done on existing wells in the area to provide a continuous shale pore pressure curve. In real time the procedure results in a cone of uncertainty that extends ahead of the bit. As drilling proceeds the cone of uncertainty collapses at any given depth below the bit. These techniques can also be used to estimate pre-drill pore pressure from seismic data.

A unique 1.5D basin model was developed for pre-drill pore pressure prediction. It is not a flow model, there is no connection between control points. It is based on a full basin model that was simplified for pore pressure estimation. Creation of a model is similar to the 2D basin models we all have used. It begins with breaking out the section and creating a burial history profile at control point (well or seismic). A conventional basin model needs to be populated with detailed estimates of rock properties such as compaction rates, initial porosity, organic content, permeability relationships, etc. In the 1.5D pore pressure basin model the control points are scattered in map view and consist of pore pressure and porosity as a function of depth along with a burial history curve. This calibration data is provided by the analysis of well or seismic data as previously described. At each location the following initial information for each formation is estimated by the modeler, initial porosity, compaction constant, specific area, effective lateral conduction, and effective hydrocarbon generation. Initial estimates consist of most likely and max/minimum values, for each formation, at each control point. At each control point the best fit values for each formation is then calculated using numerical techniques. The operator then attempts to modify the values for each formation at each control point such that 3 or 4 of the 5 factors have no or little variation between wells. These spatially simplified parameters do not represent the real world variations but are closely related to them. These values can be mapped and adjusted as geologic conditions suggest. The model is able to generate near correct pore pressures at any location within and adjacent to the control point space by interpolation or extrapolation. As new data is available by continued drilling, or new seismic in the area, the model is easily updated. Run times are measured in minutes and simplification of parameters can be accomplished in tens of minutes.

It is suggested that the pore pressure estimates from this model as well as the parameters the produce these pressures can be used to constrain conventional basin models.