Recent Advances in Pore Pressure Prediction in Complex Geologic Environments

Alan R. Huffman[1,2]

[1]Sigma Cubed Inc., 4700 W. Sam Houston Pkwy. N., Ste. 150. Houston, Texas 77041

[2]Currently at: HighPeak Energy Partners, 2421 W. 3rd St., Ste. 1000 Fort Worth, Texas 76102

GCAGS Explore & Discover Article #00343*
http://www.gcags.org/exploreanddiscover/2018/00343_huffman.pdf
Posted September 29, 2018.

*Article based on an extended abstract published in the *GCAGS Transactions* (see footnote reference below), which is available as part of the entire 2018 *GCAGS Transactions* volume via the GCAGS Bookstore at the Bureau of Economic Geology (www.beg.utexas.edu) or as an individual document via AAPG Datapages, Inc. (www.datapages.com), and delivered as an oral presentation at the 68th Annual GCAGS Convention and 65th Annual GCSSEPM Meeting in Shreveport, Louisiana, September 30–October 2, 2018.

EXTENDED ABSTRACT

Pre-drill pressure prediction using geophysical data and methods has historically been done using very simple models and has been restricted by overly simplistic estimates of the Earth's velocity field. Geopressure prediction techniques have started incorporating more sophisticated velocity methods such as amplitude variations with offset (AVO)–based phase mismatch algorithms, tomography, and prestack inversion. These technologies allow the geophysicist to obtain higher resolution estimates of the velocity field in the subsurface that can significantly improve the results of pressure prediction. These technologies permit more robust analysis of P–wave velocities in the presence of contamination from hydrocarbon effects and non-clastic rocks that have been a problem in the past.

In recent years, methods have been developed to enable robust pressure prediction in the presence of multiple pressure mechanisms including undercompaction, unloading processes (secondary pressure mechanisms) and at great depth, the onset of secondary chemical compaction. These models utilize geological and geophysical information to constrain the calibration models and the depths at which they must be applied to develop a multi-layer pressure calibration model that will accurately predict pressures for prospect-level analysis and pre-drill prediction. These models are then integrated with the velocity field and the geological and geophysical information to predict pore pressures and fracture pressures at greater depths than have been previously feasible. This methodology has been tested in multiple basins and has been proven to be effective in helping drilling engineers improve well performance through more effective mud and casing program designs that significantly reduces well costs and rig time.

Recent application of elastic and acoustic inversion in complex carbonate environments have also proven effective in predicting pressures in environments where the shales can be separated from the carbonates. The approach requires that the inverted data be decomposed into the shale and carbonate velocity trends to allow the shales to be used for effective stress prediction while the complete velocity field is used for time-depth conversion. These studies have revealed that pore pressure prediction from mixed lithology (carbonate and shale) environments is feasible using advanced inversion meth-

Originally published as: Huffman, A. R., 2018, Recent advances in pore pressure prediction in complex geologic environments: Gulf Coast Association of Geological Societies Transactions, v. 68, p. 591–595.

ods. Successful pressure prediction in this type of geology requires seismic data that is of sufficient quality to enable a robust acoustic and/or elastic inversion to be performed that can separate the shale velocities for effective stress calculation, and perform time-depth conversion from the complete velocity field If successful, the velocities for the carbonate rocks in the inversion can also be used with offset well control to calibrate reservoir quality, although this requires interpretation of lithology which can be ambiguous when the carbonates have high porosities and low velocities that approach the shale values. As the amount of shale present in the geologic section becomes smaller, the ability to predict pressures decreases. The presence of marls also presents a problem because the carbonate material within the shale suppresses the sensitivity of the shale velocity to pore pressure.

The traditional velocity-based method and the advanced inversion method will both be demonstrated with two real case histories from a complex carbonate marine environment in offshore North Africa and a Gulf Coast Salt Dome. Figures 1 and 2 show the pre-drill and post-drill results from the Barracuda well in North Africa. Figures 3 and 4 show the predrill and post-drill results from the Garden Island Bay well in Louisiana.