Enhanced seismic impact for accurate Pore Pressure Prediction. S.E. Trinidad & Tobago Case.

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Summary

Unexpected overpressure is one of the major causes of drilling hazards; it is the reason why pore pressure prediction is very important for drilling companies, especially because can reduce risk and ensure safe well engineering.

Pore pressure prediction can be performed using well data at the wellbore (1D) or use seismic data for 3D or 2D Pore Pressure Distribution (3DPPD / 2DPPD). Usually, pre-drill estimates of pore pressure are derived from surface seismic data by first estimating seismic velocities and then utilizing velocity-to-effective stress transforms appropriate for a given area combined with an estimated overburden stress to obtain pore pressure. Seismic methods detect changes of interval velocities with depth, where seismic interpretation and determination of rock properties are related to pore pressure (Bell, 2002). Seismic interval velocities get influenced by changes in properties such as porosities, fluids, effective stress, etc., and this is exhibited in terms of reflection amplitudes in seismic surveys. Consequently, less uncertainty velocity determination is less uncertainty in pore pressure prediction, and its determination is the key to get better results.

This paper shows the impact of velocity model building from a seismic enhanced dataset with higher vertical resolution, and how affects the accuracy of predicting the pore pressure in exploration areas. It guarantees the geological influence on the generation of velocity model, making them more precise.

A study case on Trinidad and Tobago showed the effect of building a basic velocity model using the original input data's sampling interval versus a model built from data enhanced by spectral extrapolation of seismic bandwidth, thereby improving seismic resolution where the surfaces were interpreted with more definition resulting in an accurate velocity model and therefore suitable pore pressure prediction analysis.

Introduction

Seismic data is a key factor in the exploration areas, especially when they have a high vertical resolution where structural and stratigraphic features can be easily identified or interpreted. This enhanced data can be obtained by several methods of spectral enhancement techniques. Basically, it boosts the seismic signal with distinguishable frequency content in order to extend the high-frequency content of the data, resulting in an improved vertical resolution of events thereby improving interpretability. The enhanced seismic plays an important role in the determination of an accurate seismic-well tie, therefore more precise seismic interpretation, sharp attribute extractions, precise seismic inversion and robust velocity model.

High sensitive velocity models can be used in the prediction of pore pressure analysis, not only to avoid safety issues but also to keep cost-effective wells during the drilling phase. It is also critical for assessing exploration risk factors especially in compressive basins, including the migration of formation fluids and

seal integrity. In cases of extreme overestimation, the mud pressure may destroy seal integrity. (Matthews, 2016).

The best way to predict a hazard in exploration areas is by the use of seismic surveys such as 2D lines or 3D volumes. However, in the case of pore pressure prediction is through velocity models. While a range of disciplines are involved and needed in a comprehensive pore pressure analysis, geophysicists play a key role in many ways (Bruce, 2002). In spite of the existence of few direct methods to calibrate a prediction such as a wireline pressure tests, there are indirect methods such as seismic surveys that are sensible enough to detect velocities variations on a specific interval. These changes come from the anisotropy of the layer analyzed as well as the effective stress. Normally a pressured section is described as lower effective stresses and lower interval velocities as well as higher porosities, lower porosities and bulk densities, higher temperatures, and higher Poisson's ratios (Dutta, 2002).

Those seismic interval velocities get influenced by changes in each of these properties especially for the effective stress because it is dependable on the variations of the pore pressure and overburden (Zhang J. 2011), whether combined or not, affecting in terms of reflection the amplitudes in seismic surveys. Therefore, an accurate velocity determination from an enhanced seismic survey is the key to pore pressure prediction.

This paper demonstrates a workflow and example about the impact of an enhanced seismic data affects velocity modeling and its integration to predict 1D pore pressure and 1D geomechanical model in exploration areas.

Method

The classical approach of pore pressure prediction in exploratory fields is considered in the present study. In general, offset well's logs and the interval velocity from surface seismic data are the only information available in exploratory fields. The prediction of the distribution of the pressure vertically and its lateral continuity is affected by the type of basin, the geologic structure, and the variation of effective stress. Therefore, the determination of the best velocity model in a compressive basin to predict pore pressure in a new well location is still a challenge, and the offset well's data is not always enough.

The first step is to create 1D pore pressure model (1DPP) at the closest well to the seismic data. The theory based on Terzaghi's and Biot's effective stress law (Biot, 1941; Terzaghi et al.,1996) for pore pressure prediction is applied in this study using the following logs: resistivity (RT), travel transit time (DT), porosity and density (RHOB). Similarly, Bowers method is applied to the velocity data (Bowers, 2001). Above all, calculations were made using empirical methods considering the deviations of the formation properties (porosity indicators) from an expected or Normal Compaction Trend (NCT), (Eaton, 1975).

Second, the seismic 2D data is enhanced through the bandwidth extension technique by increasing the seismic resolution almost three times, providing more stratigraphic and structural features helping to have a neat well-seismic tie. Then, a robust and sensitive velocity modeling from the seismic enhanced is built.

Finally, the integration of the 1D pore pressure model and the sensible velocity model predicts more precise the pore pressure values at the remote well location than the model from a low vertical seismic resolution.

Examples

The workflow has been tested on a dataset from the Ortoire area at South East in Trinidad and Tobago. The dataset included compressional sonic, density and resistivities logs from wells over a 2D seismic line. A detailed rock physics study was undertaken to QC the sonic and density logs data and to understand the relationship between the local geology and the rock properties.

Then, the 1D pore pressure model was integrated along a sensitive velocity model built from an enhanced 2D seismic line with higher vertical resolution. A blind test was developed confirming the pore pressure anomalies in the area suggested by this methodology compared with the one with low vertical seismic resolution.

Conclusions

The results can be used to understand more the importance of having a high vertical seismic resolution data to determine or estimate the nature of the reservoir and characteristics of anomalous pressure behavior including initial pressures and its prediction at a remote well location along a 2D seismic line.

Acknowledgements

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