9th Biennial International Conference
& Exposition on Petroleum Geophysics

"HYDERABAD 2012"

P-528

# Targeted tight & shale gas development: Quantitative estimation of lithological and geomechanical reservoir quality parameters from seismic data

***Eric Bathellier,*** *CGGVeritas*
***Jon Downton,*** *Hampson-Russell, CGGVeritas*
***Arcangelo Sena,*** *formerly Hampson-Russell, now ConocoPhillips*
***Adrian Smith*,*** *Hampson Russell, CGGVeritas*

3D Seismic data plays a significant role in the exploration and development of conventional reservoirs, but what role can it play in the development of "tight" or unconventional reservoirs?

Work over the last decade on seismic azimuthal anisotropy has identified a link between fracture density and orientation observed by well logs and the intensity and orientation of the observed anisotropy. Recent work, including Downton et al. 2010, has correlated these measurements to provide quantitative estimates of fracture density from 3D wide-azimuth seismic data for tight gas sands.

The work highlights the impact of advanced seismic processing in successfully recovering reliable fracture estimates which correlate well with borehole observations. These kind of areal, quantitative estimates of fracture density provide a valuable tool to guide drilling and completion programs in tight reservoirs.

Building upon this work and considering shale gas plays in particular we need to consider some additional reservoir quality indicators whilst trying to impose the same quantitative approach on the interpretation of seismic data and correlation with borehole logging observations.

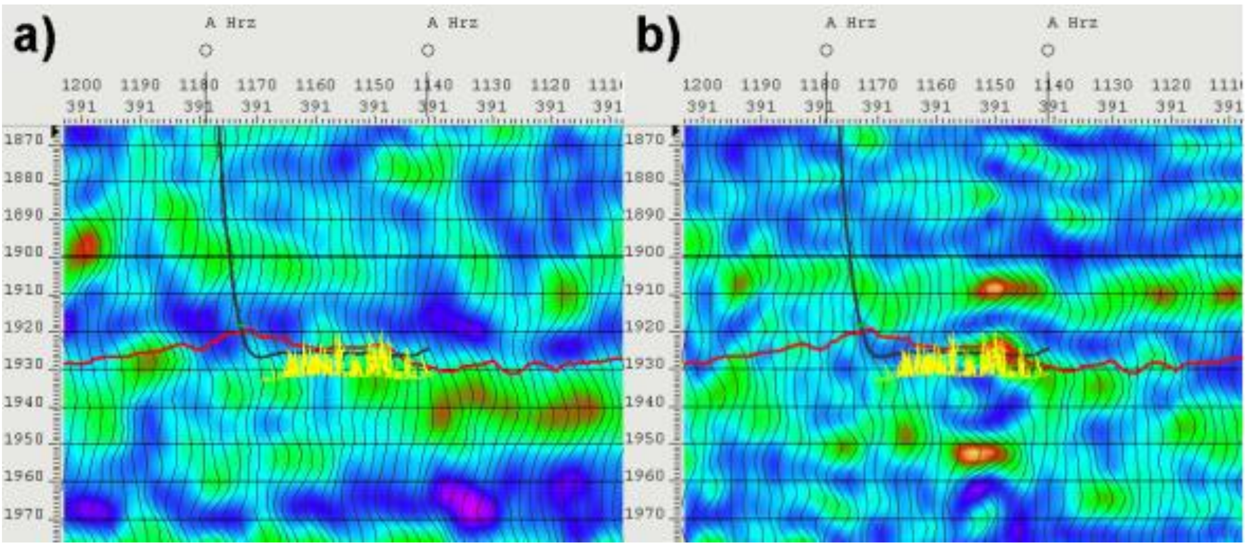


Figure 1: Seismic profile showing Anisotropic Gradient for a) raw and b) interpolated 3D wide-azimuth seismic data. The FMI fracture density superimposed in yellow.

The characterization of shale plays involves and understanding of the reservoir matrix properties as well as the in-situ stresses and fracturing that will determine optimal producing zones.

Pre-stack seismic data can help in the identification of sweet spots in shale resource plays through detailed reservoir oriented gather conditioning followed by pre-stack seismic inversion and multi-attribute analysis. This analysis provides host rock geomechanical properties such as acoustic impedance, Poisson's ratio, and Young's Modulus, among others. These properties are in turn related to quantitative reservoir properties such as porosity, mineral and TOC content, and brittleness.

In this presentation we show an integrated seismic approach based on pre-stack azimuthal seismic data analysis and well log information to identify sweet spots, estimate geomechanical properties and in situ principal stresses.

Additionally, the analysis of azimuthally processed seismic gathers through azimuthal velocity and AVO analysis and its combination with geo-mechanical properties can be used to predict the in-situ stresses acting on shale reservoirs. Well log data also provide the link to in-situ stress estimation from seismic, via pore pressure analysis. In particular, we estimate the differential horizontal stress ratio and fracture initiation pressure from the Young's modulus, Poisson's ratio and a normal compliance factor, using a newly developed technique. Optimal zones exhibit relatively high values of Young's modulus (more brittle) and low differential horizontal stress ratio (no preferential orientation). Such zones are prone to fracturing and tend to fracture randomly; producing fracture swarms when completed and thus potentially have increased production.

The main potential benefits of this integrated rock property and pre-stack/azimuthal seismic approach are:

- Better definition of reservoir drainage geometry
- Avoidance of drilling hazards
- Fracture type prediction
- Grouping reservoir intervals with similar stress profiles for optimal stage zoning in hydraulic fracture stimulation
- Better well placement for field development

Young's Modulus estimated from seismic data with plates showing the Differential Horizontal Stress Ratio (DHSR) and direction of local Maximum Horizontal Stress. High brittleness zones are better for hydraulic fracturing. Low DHSR zones are where fracture swarms will form, and high DHSR zones are where aligned fractures will occur.

This paper discusses the methodology and validation using a case study area onshore USA.

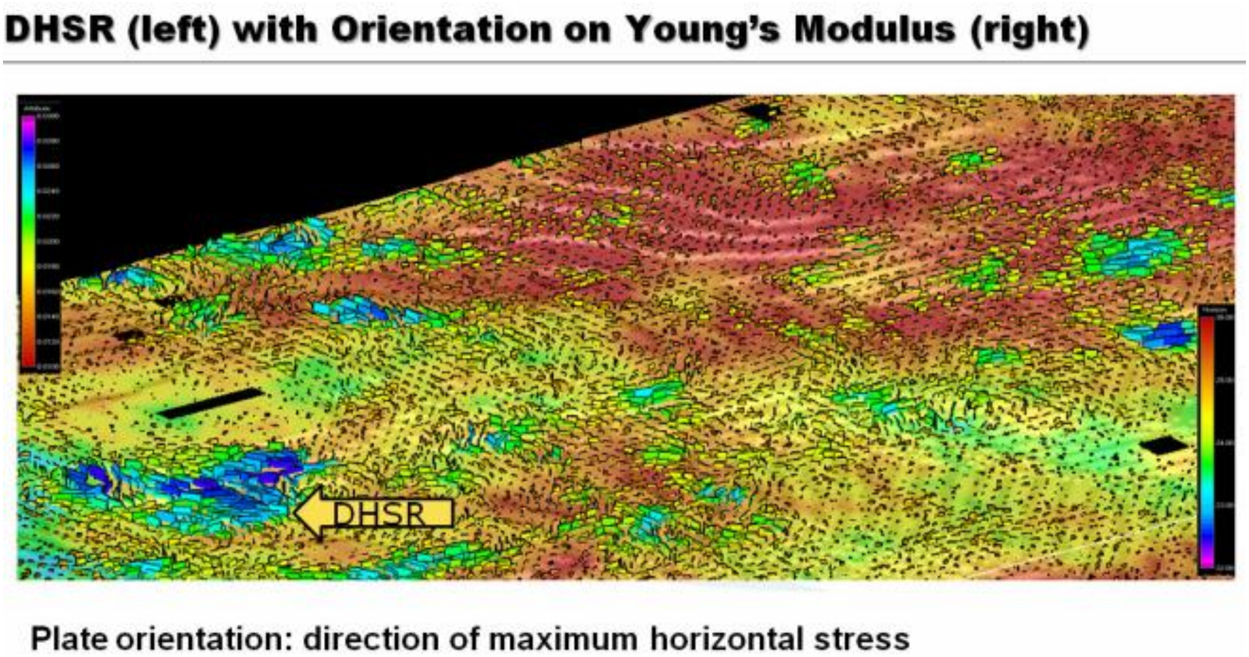


Figure 2: Plot of prognosed brittleness and DHST