MEDWIN PUBLISHERS
Committed to create value for Researchers

Petroleum & Petrochemical Engineering Journal

Anisotropic Rock Physics Model Based Statistical Inversion

Xiaoyang Wu*

Edinburgh Anisotropic Project, British Geological Survey, UK

***Corresponding author:** Xiaoyang Wu, Edinburgh Anisotropic Project, British Geological Survey, The Lyell Centre, Research Avenue South, Edinburgh, EH14 4AP, UK, Email: xywu@bgs.ac.uk

Mini Review

Volume 1 Issue 2

Received Date: May 13, 2017

Published Date: May 30, 2017

DOI: 10.23880/ppej-16000113

Introduction

Fracture detection using seismic response is typically carried out using methods which do not depend on details of the underlying anisotropic rock physics. Such methods may include ellipse fitting of a suitable seismic attribute followed by the assumption that the ratio of major to minor axes is proportional to fracture density. Other methods are based around fitting amplitudes to the Ruger (1998) equation, and assuming that the "anisotropic gradient" term is a fracture indicator. Recent experimental work on realistic synthetic rock with controlled fracture properties indicated that the anisotropic parameters are a complex function of fracture, fluid and rock types. Better understanding the rock physics mechanism of fractured reservoir will improve the ability of using anisotropic rock physics relations for quantitative estimation of fracture properties. In this paper, a methodology is in traduced for the simultaneous inversion of facies and fracture properties from seismic measurement. It includes anisotropic rock physics theory, reflection calculation and statistical inversion.

Anisotropic Rock Physics Theory

Understanding the reservoir rock type, pore geometry, saturated fluids and fracture systems is a key issue for the choice of appropriate anisotropic rock physics model. These knowledge can be derived from the X-Ray Diffraction (XRD), the Scanning Electron Microscope (SEM) analyses and the Formation Micro-Imaging (FMI). Hudson's model for cracked media characterize Transversely Isotropic (TI) media with horizontal or vertical cracks, which can be applied to scenarios such as hydraulically fractured shales [1]. Schoenberg and Heiberg proposed an orthorhombic model to estimate the elastic stiffness of Transversely Isotropic (TI) medium with a set of vertical fractures [2]. This model can be used to estimate the elastic stiffness of laminated shales with vertical fractures. Xiaoyang Wu introduced a general rock physics modelling process to estimate the elastic properties from mineralogy and rock texture by combination of different rock physics models [3].

Reflection Calculation

An efficient approach to calculate the seismic reflections from elastic properties is using approximations from Zoeppritz equations. For weakly anisotropy, simple approximation such as equation can be used to calculate the reflection coefficient, as well as analyse the relation of anisotropic parameters with seismic Amplitude Versus Offset and AZimuth (AVOAZ) response [4]. The limitation of these approximations is the error becomes obvious at large offset. Schoenberg and Protazio proposed an explicit solution to the Zoeppritz equation for the calculation of plane-wave reflection and transmission coefficients [5]. This method was used to calculate the AVOAZ response from the interface of HTI-orthorhombic shale media [6].

Statistical Inversion

The Bayesian theorem is used for estimating posterior probability of facies and rock properties. In this method, a set of seismic facies is defined, together with a prior probability distribution for each, which can be derived statistically from drilling. Within each facies f, a P-wave and S-wave velocities relation, as well as prior probability distributions for P-wave velocity, porosity phi, water saturation Swand fracture densityfd are defined from well log data. This allows to forward model the AVOAZ response for each realization of facies and rock properties through appropriate sampling techniques such as Monte

Carlo or Markov Chain Monte Carlo samplings. Then the posterior probability of each facies and model parameters when given seismic data is derived from the prior probability and the likelihood function which describe the similarity of forward modelling data with real seismic data [7].

Conclusion

This paper introduces anisotropic rock physics models into the fractured reservoir characterization process. The statistical inversion comprehensively combines prior knowledge from well log, core samples or laboratory measurement with azimuthal seismic response to estimate the posterior probability of facies and fracture properties. A potential application is to differentiate facies from seismic response and further estimate anisotropic parameters related to fractured reservoirs, as well as its saturated fluids. These methods can also be applied to analyse the brittleness of shales and the seismic response before and after hydraulic fracturing.

References

1. Hudson JA (1981) Wave speeds and attenuation of elastic waves in material containing cracks. Geophys J R Astron Soc 64: 133-150.
2. Schoenberg M, Helbig K (1997) Orthorhombic media: Modeling elastic wave behavior in a vertically fractured earth. Geophysics 62(6): 1954-1974.
3. Xiaoyang Wu, Chapman M, Li XY, Dai H (2012) Anisotropic elastic modelling for organic shales. 74th EAGE Conference & Exhibition incorporating SPE EUROPEC, Copenhagen, Denmark.
4. Ruger A (1998) Variation of P-wave reflectivity with offset and azimuth in anisotropic media. Geophysics 63(3): 935-947.
5. Schoenberg M, Protazio J (1992) Zoeppritz rationalized and generalized to anisotropy. Journal of Seismic Exploration 1(2): 125-144.
6. Xiaoyang Wu, Richard U, Chapman M (2016) Shale anisotropic elastic modelling and seismic reflections. Journal of Seismic exploration 25(6): 527-542.
7. Xiaoyang Wu, Mark M, Xiang Li, Erika A, Patrick P (2013) Bayesian inversion for porosity and saturation using frequency-dependent rock physics models. 84th SEG International Exposition and Annual Meeting, Expanded abstract, Houston, USA.