Velocity and Attenuation Anisotropies of Shear sound waves

Charles Naville

Abstract: Shear wave velocity anisotropy is commonly measured in all frequencies, with low frequency pendulum geophones for earthquake recording, with 3 component land sensors and 4C seabed sensors (OBN type) in surface seismic for hydrocarbon surface seismic exploration and reservoir imaging, with Dipole sonic tools for near borehole wall anisotropy characterization and geomechanical stress investigation, and with ultrasonic source and sensors to analyze rock core samples.

Examples of early dipole sonic measurements recorded in France in the early 1990's are presented, using two methods of S-wave anisotropy detection which integration remains to be industrially implemented.

In contrast, S-wave anisotropy investigators rarely explore the S- wave anisotropy of attenuation from the recorded Split S-wave signals.

An early example of Shear wave differential attenuation is exposed from an in-house physical model built as a stack of thin metallic cards compressed by a variable force with bolt and nuts, resulting with large differential attenuation of split S-wave propagated parallel to the stacked metallic sheets.

An early example of reliable surface seismic converted PS-wave results from the Paris Basin exhibits uncorrelated and consistent velocity anisotropy and attenuation anisotropy of split S-waves in the 0-1000m upper layers, still poorly understood, in the vicinity of a major fault, and totally invisible in P-wave reflection seismic.

Presenter Bio: **Charles Naville**

Background: Engineer, Polytechnique-Paris 1973 & ENSPM

Geophysicist in CGG 1977-1989, field assignments in Gabon, USSR, USA, France,

Geophysicist in IFPEN-France, 1990-present.

Activity in Seismic processing and R&D, surface and borehole seismic.

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TI anisotropy characterization on basis of sonic data sets from multiple wells: A Norwegian Sea case study

Jeroen Jocker

Abstract

The presence of elastic anisotropy is a well-known issue in seismic inversion and also in various geomechanics workflows. Failing to take anisotropy into account yields biased estimates of subsurface velocity, consequently resulting in mis-positioning of seismic reflectors, erroneous AVO response or under-estimation of in-situ stresses. In conventional depth imaging, seismic anisotropy can have a significant influence on the focusing and positioning of migrated reflection events. Shales are known to exhibit elastic anisotropy which can lead to apparent inconsistencies in log responses. To address these issues and verticalize the velocities, shale anisotropy characterization becomes critical. This talk describes a workflow where sonic slowness measurements from multiple wells are used to derive the anisotropic elastic TI properties of the formation, commonly referred to as Thomsen parameters.

Presenter Bio: **Jeroen Jocker** is an Acoustic Domain Expert in SLB located in The Hague, Netherlands.

He holds a Master Degree in Petroleum Engineering and a PhD in Geophysics, focusing on ultrasonic wave propagation in heterogeneous elastic and poroelastic media.

Jeroen started his SLB career in 2006 as a Research Scientist. In his current role as Acoustic Domain Expert, he works on research and technical projects related to acoustics in Europe and Africa.

An example of multi-well / multi-scale approach for anisotropy characterization and correction.

Pascal Debec

Abstract: Elastic parameters derived from crossed dipole acquisition in wells can be used to estimate a difference between fast and slow shear. However, it does not always allow to fully estimate Thomsen parameters, unless the same formation is logged in different relative dip positions. A multi-well approach, integrating regional bed dipping, is often the only way to quantify epsilon, delta and gamma and finally remove the effect of anisotropy from the Vp and Vs logs.

Presenter Bio: **Pascal Debec** started in 1993 to work on sedimentology and seismic stratigraphy, before slowly sliding toward Quantitative Seismic Interpretation, AVO, and Rock Physics. An alternance of operational positions in expatriation and technical center positions in France during 15 years led Pascal to join the Well Acquisition and Interpretation department, in Pau, France, where he has been in charge of the Rock Physics team for 10 years, and promoted Senior Specialist in Seismic Reservoir Characterization 5 years ago. Today, his focus is on Acoustic Logs, Rock Physics Models and their transverse applications to Pore Pressure, AVO, QSI and 4D.

Machine Learning Enabled Automatic Borehole Sonic Shear Processing

Lin Liang and Ting Lei

Abstract

Borehole sonic processing traditionally relied on acoustic expertise and was a time-consuming process. It was not uncommon to see inconsistent processing results delivered by different experts and discrepancies between WL and LWD sonic deliveries. We have therefore developed fully automated solutions to address these challenges and modernize borehole sonic interpretation. In this work, we have trained accurate and efficient surrogate models to replace expensive and unstable mode search solvers. These models, combined with clustering and progressive fitting algorithms, provide a method to automatically label, extract, and invert specific borehole sonic modes to obtain relevant information about borehole and formation properties, including formation shear slowness and mud slowness. We have also developed a dispersion-based fitting wellness metric for robust quality control, helping to build confidence in delivering sonic interpretation for downstream applications. This new progress has enabled a paradigm shift in the application of sonic measurement for geomechanics, petrophysics, and other related fields.

Presenter Bio: Lin Liang is a scientific advisor and program manager in Schlumberger-Doll Research in Cambridge, Massachusetts, USA. He works on multiphysics modeling and inversion for hydrocarbon exploration and reservoir characterization and reservoir simulation and history matching problems, as well as the application of data science and machine learning techniques to exploration and field development. Lin holds a BS degree in fluid machinery and fluid engineering from Tsinghua University and a Ph.D. degree in environmental science from Peking University. Lin joined Schlumberger in 2002. He is a member of SEG, SPE, and SPWLA.

Presenter Bio: **Ting Lei** is a principal research scientist in the Advanced Acoustics program in Schlumberger-Doll Research, Cambridge, Massachusetts. He joined Schlumberger in China in 2006. In 2009, he moved to Schlumberger-Doll Research in Cambridge, Massachusetts, USA. Ting has been working on numerical modeling for complex acoustic problems and development of inversion algorithms using borehole sonic data. Ting received his Ph.D. degree in Engineering Mechanics from Tsinghua University in China in 2006.
