

Poisson Impedance : A promising tool for determination of sand quality.

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Summary

We demonstrate the separation of sand stone reservoir from shale where gas sand and shale have almost similar P -, S -impedance contrast using Poisson Impedance (PI). The correlation coefficients between PI curve (with different c values) versus Gamma ray and Water saturation curve are computed. The c value corresponding to maximum correlation coefficient for GR is used to compute another attribute namely *lithology impedance* (LI). Similarly, *fluid impedance* (FI) is computed using c value that corresponds to maximum correlation coefficient for Sw curve. The cross-plot between LI and GR shows the advantages of LI in distinguishing sandstone from shale. Fluid content is predicted using the linear relationship exhibited on the cross-plot of FI versus Sw .

Introduction

Increasing demand of oil and gas motivates geoscientists to explore new reservoirs. For doing so it is required to differentiate lithology and fluids in the reservoir. Basically, Bulk modulus (k), Shear modulus (μ), Young modulus (E) and Lambda (λ) attributes are used for discriminating lithology (sandstones versus shale) or fluids (gas, oil, water). P wave velocity (V_P), S wave velocity (V_S) or P impedance (I_P), S impedance (I_S) and density (ρ) are prerequisites for the computation of all the attributes mentioned above. Over the last few years, pre-stack seismic inversion has been used to estimate these prerequisites. This seismic inversion yields I_P , I_S , Poisson's ratio via V_P/V_S ratio and density. The robust determination of density from seismic requires really long offset noise-free data which is barely available. In order to avoid this stringent requirement of density, we compute it as its product with other attributes like $\lambda\rho$, $\mu\rho$, $k\rho$ and $E\rho$. Finally, the cross-plotting pair of these attributes is used for discriminating lithology and fluid content.

Theory and/or Method

It is well-known that the cross-plotting of I_P versus I_S for data from a thin zone enclosing the reservoir yields a cluster of points corresponding to gas sand somewhat separated from the cluster of points coming from the background shale, even-though the separation between these clusters would depend on the impedance contrast between the litho-fluid and background lithology. Moreover for enhanced separation between gas sand and background shale the $\lambda\rho$ - $\mu\rho$ cross-plot is used. This cross-plot exhibits a better separation as gas sand shows lower value of $\lambda\rho$ and high value of $\mu\rho$ than the background shale.

On these cross-plots, it may be difficult to discriminate the litho-fluid distribution where clusters are not completely separated. But in such cases, rotating the axes to be parallel with the trends would ensure a distinct discrimination of the litho-fluid distribution. This rotation can be achieved by computing

an interesting attribute namely Poisson Impedance (Quakenbush, et.al 2006). It incorporates the information of Poisson's ratio and density.

Mathematically it can be expressed as

$$PI = I_P - cI_S.$$

where c is the term that optimizes the rotation. The value of c needs to be determined from the regression line of the cross-plot of the I_P and I_S logs for the wet trend. The inverse of the slope could be used as the c value. Additionally, target correlation coefficient analysis (TCCA) method (Tian, et. al. 2010) can be used to calculate c .

The automatically generated correlation coefficient between the PI curve with different c values and Gamma Ray and water saturation curve is computed. The c value corresponding to maximum correlation coefficient for GR is used to compute an attribute that would emphasize lithology and so is known as lithology impedance (LI). Similarly, fluid impedance (FI) is computed using c value that corresponds to maximum correlation coefficient for Sw curve (Angga Direzza, et.al. 2012). Cross-plots between LI and GR can now be constructed that show the advantage of LI in distinguishing sandstone from shale. Fluid content is predicted using the linear relationship exhibited on the cross-plot of FI versus Sw .

Conclusions

In conclusion, PI is very favorable attribute for sandstone reservoir characterization. Using TCCA method, we can derive two attributes of PI namely Lithology Impedance (LI) and Fluid Impedance (FI). The results on log data show that sandstone and shale can be well distinguished by LI . Also FI provides a potential fluid content identification. Integrating with geological, petrophysical, and well test data, the sandstone reservoir can be characterized properly and new prospect can be identified directly.

Acknowledgements

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References

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Tian, et. al., 2010, Reservoir prediction using Poisson Impedance in Quinhuangdao, Bohai Sea : SEG Denver 2010 Annual Meeting, 2261-2264.