# 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 λρ, μρ, *kρ* and *E*ρ. 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 λρ-μρ cross-plot is used. This cross-plot exhibits a better separation as gas sand shows lower value of λρ and high value of μρ 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.


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### References


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