Comparison of Advanced Seismic Attributes for Lithofacies Discrimination: A Petrophysics Perspective

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ABSTRACT

Attribute analysis is considered to be an important step in any seismic reservoir characterization study. Diverse attributes can be investigated in order to obtain a thorough view over the characteristics of different reservoir lithofacies. The choice of drilling new locations or development planning of the existing wells relies critically on the results acquired in this stage. In this study, Lame parameters of incompressibility and rigidity, Poisson Impedance and Poisson Dampening Factor are analyzed to compare their effectiveness in discriminating lithofacies at the only well available in the study area. The result of Poisson Impedance and lame parameters crossplot analysis were consistent. Moreover, crossplot of Poisson Dampening Factor respect to Poisson Impedance can be used to determine the quality of the reservoir.

Key words: Poisson Impedance, Poisson Dampening Factor, Lame Parameters, Attribute analysis.

INTRODUCTION

Goodway et al. proposed lame parameters as an effective tool for identifying different lithofacies. Zhou and Hilterman (2010) deduced that clusters of different lithofacies have larger separation in λρ-μρ crossplot than in AI-SI space . These attributes are defined as:

$$\lambda\rho = AI^2 - 2 * SI^2 \quad (2)$$

$$\mu\rho = SI^2 \quad (3)$$

Where λ, μ, *AI* and *SI* are incompressibility, rigidity, Acoustic Impedance and Shear Impedance, respectively.

Poisson Impedance, PI, is comparatively a modern attribute which unite the benefits of Poisson Ratio (□) and density into a unique attribute (Quakenbush et al., 2006). Crossplot of Acoustic Impedance versus Shear Impedance fails to delineate different lithofacies; however, by an efficient rotation of the crossplot this goal is achieved. The constant C determines the amount of rotation (Prakash et al., 2012). The following formula defines Poisson Impedance:

$$PI = AI - C * SI \quad (4)$$

Poisson Dampening Factor (*PDF*) was the offspring of Poisson Impedance introduced by Mazumdar (2007). It was shown that PDF has higher sensitivity to hydrocarbon pore volume as compared to PI and that the distribution of gas sands in PDF space is much broader than in PI space (Mazumdar, 2007). PDF is defined according to the following equation:

$$\sigma = PI * PDF \quad (5)$$

The focus of this paper is on the application of Poisson Impedance, Poisson Dampening Factor (PDF) and lame parameters of incompressibility and rigidity to discriminate productive zone of the reservoir with a petrophysics perspective with the only well data available. However, the rock and fluid properties obtained at the well location can be generalized deterministically or statistically to the whole seismic volume of study in case of appropriate well to seismic tie (Pelletier and Gunderson, 2004).

METHODOLOGY

After the well logs are environmentally corrected, Elastic Impedance, Poisson Impedance, PDF, λρ and μρ logs are generated at the well location. The constant C used in the Poisson Impedance formula is determined as the reciprocal of the slope of the crossplot of SI versus AI. As it is clear from Figure 1, the slope of the regression line is 0.67 hence the C value will be 1.49. In the next step, different attribute crossplots are analyzed to determine the most prominent attribute for detailed lithofacies characterization.

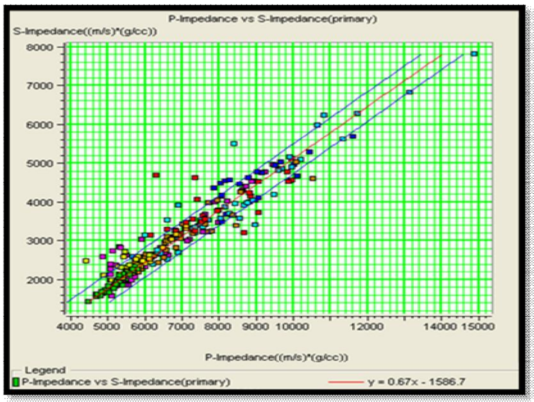

Figure 1. The crossplot of P-Impedance versus S-Impedance at the well location. The slope of the regression line is 0.67 so the C value is 1.49.

RESULTS

The crossplot of Lambda-Rho versus Mu-Rho at the well location is depicted in Figure 2. The color key is volume of clay. The blue color depicts Hydrocarbon bearing sandstones, the green shows tight sandstones and pink is shale. Figure 3 shows the selected zones as a function of depth.

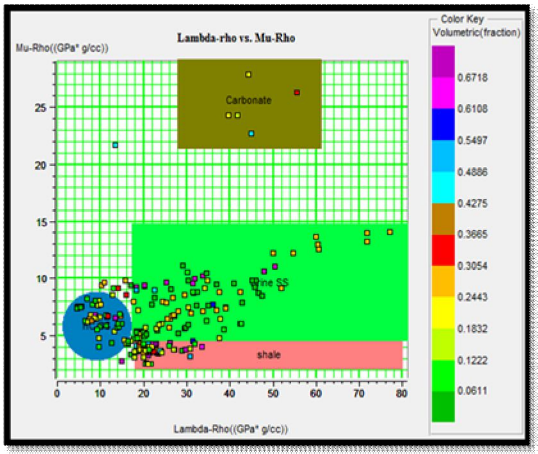

Figure 2. The crossplot of Lambda-Rho versus Mu-Rho at the well location.

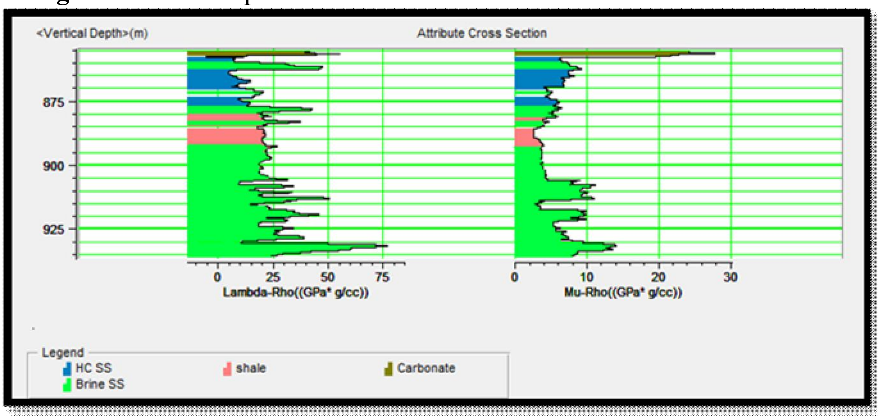

Figure 3. Different zones depicted as a function of depth at the well location.

Crossplot of Poisson Impedance versus depth is displyed in Figure 4. The color key is volume of clay. The blue color is hydrocarbon sandstone, the pink is shale and the green is tight sandstone. Figre 5 illustrates the separated zones of the crossplot as a function of depth.

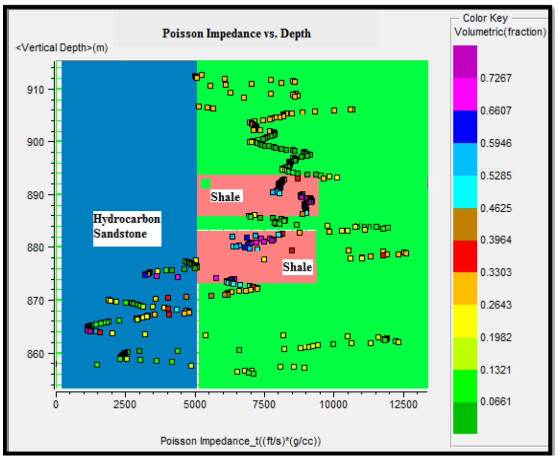

Figure 4. The crossplot of Poisson Impedance versus depth at the well location.

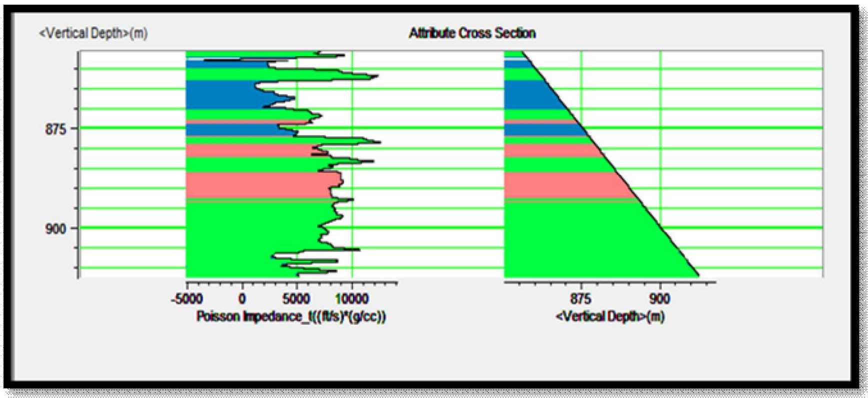

Figure 5. The selected zones as a function of depth at the well location. .

The crossplot of PDF versus Poisson Impedance at the well location is shown in Figure 6. The color key is water saturation. Note the decrease in Poisson Impedance is attributed to the decrease in density which in turn the existence of reservoir. The higher the PDF value the cleaner the reservoir, i.e., the higher the reservoir quality.

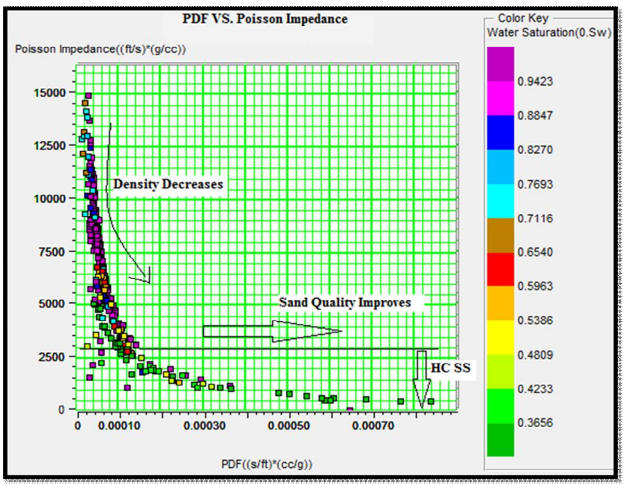

Figure 6. The crossplot of PDF versus Poisson Impedance at the well location.

CONCLUSION

The result of λρ-μρ crossplot analysis was consistent with the crossplot of Poisson Impedance with depth. The major conclusion that can be drawn here is that Poisson Impedance is inherently a perfect attribute for lithofacies discrimination which does not need to be crossplotted against a second attribute to give results. However, famous λρ and μρ attributes needed to be used simultaneously in order to get desirable results. Moreover, the crossplot of PDF versus Poisson Impedance was revealed to be an outstanding tool for reservoir quality determination. In other words, PDF is a more robust attribute than Poisson Impedance in delineating clean reservoir zones. Litho-fluid properties obtained at the well location can be generalized deterministically or statistically through the whole volume of study providing optimum well to seismic tie.

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