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Uncertainty reduction in characterization of Vaca Muerta shale

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Summary

The Late Jurassic-Early Cretaceous Vaca Muerta (VM) Formation in the Neuquén Basin has served as an important source rock for many of the conventional oil and gas fields in Argentina. With the interest in developing and exploiting the shale resources in the country, many companies there have undertaken the characterization of the VM Formation in terms of the elements of shale plays.

Shale plays can be identified based on, amongst other characteristics, the total organic carbon (TOC), as better TOC leads to the better production. However, there is no way of measuring it directly using seismic data, and can only be estimated in an indirect way. Considering the influence of TOC on compressional, shear velocities and density, geoscientists have attempted to compute it using the linear or nonlinear relationship it may have with P-impedance. Understanding the uncertainty in using such a relationship for characterizing VM formation, a different approach has been followed for characterizing it. In addition to P-impedance, gamma ray (GR) is another parameter of interest for characterizing the VM Formation as a linear relationship seems to exist between GR and TOC.

In this study, using P-impedance and GR volumes, a Bayesian classification approach has been followed to obtain a reservoir model with different facies, based on TOC and the associated uncertainty with it. As the first step, we defined different facies based on the cutoff values for GR and P-impedance computed from well-log data. Having defined the different facies, Gaussian ellipses were used to capture the distribution of data in a cross-plot of GR vs P-impedance. Next, 2D probability density functions (PDF's) were created from the ellipses for each of the facies. Combining these PDF's with GR and P-impedance volumes, different facies were identified on the 3D volume. Post-stack model-based inversion was used to compute the P-impedance volume while probabilistic neural network (PNN) approach was used to compute GR volume. Both derived P-impedance and GR volumes correlated well at blind wells on the 3D volume, which lent confidence in the characterization of VM Formation.

This workflow has the potential of good application to other shale plays around the world.