ACOUSTIC AND ELECTRICAL PROPERTY CHARACTERIZATION OF THE VACA MUERTA FORMATION

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PROJECT OBJECTIVES

- Produce a comprehensive petrophysical data set (porosity, acoustic velocity, resistivity, permeability and pore structure) of the facies in the Vaca Muerta Formation.
- Define the control of mineralogy and clay content on the petrophysical properties and, in particular, the acoustic anisotropy.
- Examine the relationship between clay content, acoustic velocity and resistivity to find differences between ductile and brittle behavior of the mudstones of the Vaca Muerta Formation.

PROJECT RATIONALE

Plug samples from 1m short cores through the various facies of the Vaca Muerta Formation enable us to petrophysically characterize each facies and produce a wide-ranging catalogue that relates petrophysical properties such as porosity, acoustic velocity, resistivity and permeability to the rock composition and pore structure. Special emphasis will be given to the acoustic anisotropy of these rocks. The amount of clay also influences the anisotropy of the fissile mudstones in the Vaca Muerta Formation. The Vertical Transverse Isotropy (VTI) of these rocks is mostly used for interpretation and processing of seismic data. Yet, anisotropy needs to be taken into account in a variety of processing steps, such as normal move-out (NMO) and dip move-out (DMO) corrections, migration, and amplitude variation with offset (AVO) analysis, and depth conversion.

BACKGROUND

The compressional wave velocity is a function of porosity, the velocity of matrix (V_m), and the velocity of pore fluid (V_f) as described by the time-average equation (1) of Wyllie et al. (1956).

$$\frac{\mathbf{1}}{\boldsymbol{Vp}} = \frac{(\mathbf{1}-\emptyset)}{\boldsymbol{Vm}} - \frac{\boldsymbol{O}}{\boldsymbol{Vf}} \quad (1)$$

or by Raymer et al. (1980) whose equation (2) is adjusted for well log data.

$$\boldsymbol{Vp} = (\mathbf{1}-\emptyset)^{\mathbf{2}}\boldsymbol{Vm} + \emptyset\boldsymbol{Vf} \quad (2)$$

The acoustic velocity of the matrix is directly related to its mineralogical composition, which in mudstones is often tied to the amount of clay. Clay content influences anisotropy and the ratio between compressional and shear wave velocity (V_p/V_s). The latter is an important variable for detection of rock properties. The influence of clay content (C) in the matrix on the V_p/V_s ratio is described in the empirical equation (3) from Han et al., (1986).

$$\mathbf{V_p/V_s = 1.55 + 0.56Ø + 0.43C} \quad (3)$$

SCOPE OF WORK

Seventy-nine 1 m short cores have been drilled in key locations throughout the over 1200 m of measured sections of the Vaca Muerta Formation. These cores have previously been analyzed with regards to mineral composition, and gamma ray. This study complements these datasets with petrophysical properties (porosity, acoustic velocity, resistivity, permeability and pore structure) focusing on the anisotropy and provides VTI constants ε, δ and γ within the Vaca Muerta Formation. In addition, the variability in resistivity between the carbonate-rich intervals and pure siliciclastic rocks will be investigated.

The mineralogical data will be correlated with the petrophysical properties and used to calculate the V_p/V_s ratio in order to assess the causes of the anisotropy. Together this data set will aid in the seismic processing and, thus, reduce the interpretation risk for unconventional exploration.

SIGNIFICANCE

The planned mineral identification, determination of the distribution and quantity of clay type, and the assessment of their effects on petrophysical properties of the Vaca Muerta Formation is an innovative test of the Han et al. (1986) equation and the influence on anisotropy. Furthermore, the study will produce a comprehensive data set of mineralogical and petrophysical properties that is not yet available for organic-rich fissile mudstones targeted in unconventional plays.

Better knowledge of well documented acoustic and electrical properties of some of the facies in the Vaca Muerta Formation will improve well log interpretation. Furthermore, successful extraction of core plugs at three different angles, and elucidation of the resulting anisotropy parameters, will aid and improve seismic processing and result in better imaging. Improving 3D seismic images will add value through optimizing drilling operations and hydraulic fracturing efforts.

REFERENCES

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