CALIBRATING ACOUSTICAL AND ELECTRICAL PROPERTIES TO TOC DISTRIBUTION IN THE VACA MUERTA FORMATION, NEUQUÉN BASIN, ARGENTINA

Ralf J. Weger, Max Tenaglia, Leticia Rodriguez Blanco, Peter K. Swart, and Gregor P. Eberli

PROJECT OBJECTIVES

- Calibration of acoustical and electrical properties to TOC measurements on plug samples from the Vaca Muerta Formation.
- Document resistivity anisotropy observed in mixed carbonate-siliciclastic plug samples from the Vaca Muerta Formation.
- Determine the potential variability of TOC values derived with the ΔlogR method using horizontal v.s. vertical plugs (e.g. logs from vertical v.s. horizontal wells).

PROJECT RATIONALE

Successful exploitation of unconventional reservoirs requires the reservoir zones to be brittle, porous, and rich in organic carbon. Modeling results have shown that increasing porosity, clay content, and both kerogen and organic carbon content will decrease a rock's brittleness. Porosity and clay content can be determined from neutron and sonic measurements, allowing characterization of a formation's ductile and brittle behavior, but the properties and proportions of Kerogen and/or TOC are often more difficult to determine. One frequently used, fast, inexpensive and convenient method for Total Organic Carbon (TOC) content determination is the ΔlogR method (Passey et al., 1990) and its various revisions and improvements. This method has been applied successfully in conventional source rock evaluation for decades but is being used in unconventional plays more and more frequently. However, results derived using the ΔlogR method depend on boundary values established from existing velocity and resistivity measurements. Both boundary values and measurements (both velocity and resistivity) are highly sensitive to variations caused by anisotropy, and the degree of acoustic and electrical anisotropy is often poorly documented.

DATA SETS

Here we use electrical and acoustic properties of over 250 Vaca Muerta plug samples previously analyzed for acoustic velocity (Fig. 1). Samples were

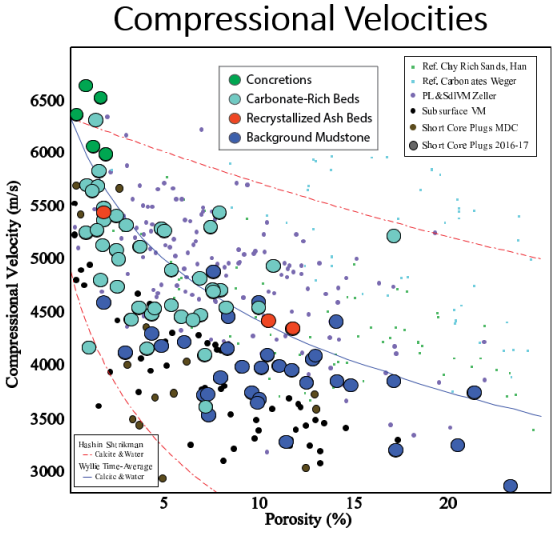

Figure 1: Compressional p-wave velocities of 250 Vaca Muerta plug samples.

derived from both outcrop and subsurface. Over 100 short cores were drilled in outcrops covering proximal to distal locations; subsurface plugs are from the El Trapial block (Weger et al., 2018).

APPROACH AND WORKFLOW

Plugs were cut in pairs or triplets at almost identical depth to determine acoustic and electrical anisotropy (Fig. 2). The method is described in more detail by Weger et al., (2016). Carbonate content was determined by crushing part of the sample and dissolving the carbonate portion using 10% hydrochloric acid. The TOC content was measured on the remaining insoluble material using an elemental analyzer. Acoustic and electrical data of mudstone samples from the Vaca Muerta Formation are compared to both geochemically derived TOC content and gamma ray measurements to provide a quantitative calibration of the TOC values derived from acoustic, electrical, and/or gamma ray measurements to geochemically measured TOC content. In particular, the availability of plug pairs (and triplets at orientation) will allow us to quantify the variations in TOC values derived with Passey's ΔlogR method if strong acoustical and electrical anisotropy exists.

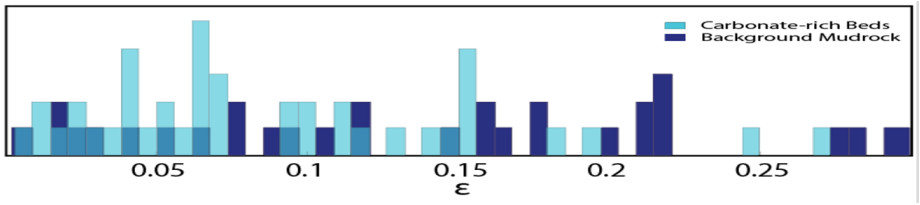

Figure 2: Velocity anisotropy parameters "ε" displaying large differences between horizontal and vertical measurements in Vaca Muerta mudstones, but very little differences in the more carbonate-rich beds of the Vaca Muerta Formation.

SIGNIFICANCE

Estimates of TOC based on spectral gamma ray provide a qualitative indication of overall organic richness but they are not precise enough to provide a reliable method to determine TOC values. The ΔlogR method on the other hand, provides a means of estimating TOC reliably in a variety of different settings and scales. The strong correlation between ΔlogR derived estimates from plugs samples and direct chemical measurements will provide the basis for reliable subsurface application in the Neuquén Basin.

REFERENCES

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