geoconvention
Calgary • Canada • May 11-13 2026

Applying Maxwell Shale Models to Colombian Data

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Summary

A workflow is presented illustrating the application of Maxwell effective media model to estimate shale elastic properties.

Workflow

Using the models developed by Sevostianov et al 2005, implemented by Sayers, 2013 and Sayers and den Boer 2018, the suitability of inorganic shale models is demonstrated using Colombian well data across different basins and depths of burial. The idea is to create a model that represents the platelet components of shale, with a defined orientation and the addition of other components (grains) as inclusions, represented as a schematic in figure 1.

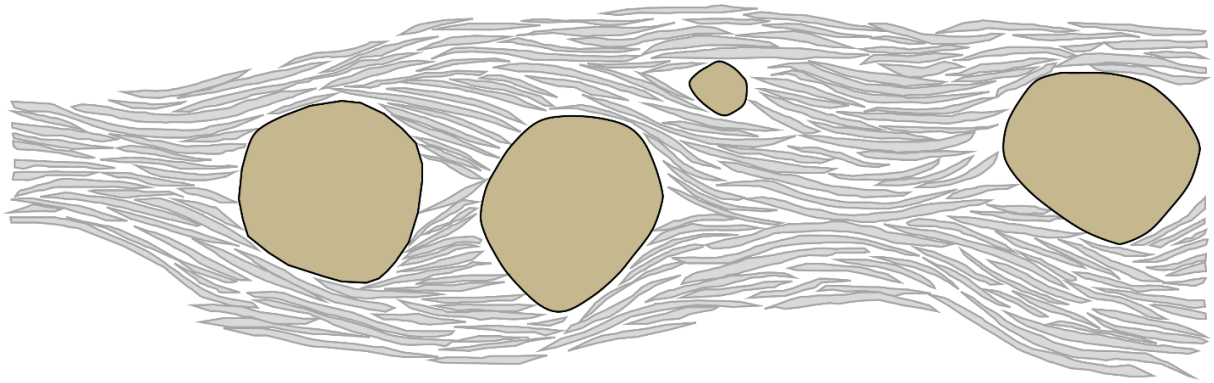


Figure 1. Shale model representation, modified from Sayers, 2024.

The model is based on defining clay particles, approximated as ellipsoids, with an interparticle layer of a water-like material. The ellipsoids within a local area (or domain) are oriented in the same direction and have a consistent aspect ratio c/a. This aspect ratio can be modified to scale the inherent anisotropy of the clay aggregate. Also, the amount of interparticle material can be used to model the range of elastic properties observed in well data typically associated with shale. The slow shales correspond to shales with high water content while the fast shales to low water content. In addition, an orientation distribution function (ODF) is added to mimic clay platelet orientation. Normally modelled as function of overburden and/or compaction, the ODF can be used as a calibration parameter or help validate any anisotropic measurements.

Once a shale has been defined, it can be combined with other components such as quartz and limestone to produce an estimate of mixed lithologies. To do this, the same Maxwell scheme is used to embed limestone inclusions with a quartz matrix, or vice versa, quartz inclusions within a limestone matrix. This composite material can then be combined again using the same scheme with the previously defined shale.

Results

Figure 2 illustrates the resulting shale line as defined by Sayer and den Boer (2018) with various amounts of bound water using a pseudo LMR representation that displays the anisotropic nature of shale. The figure also shows the impact of varying platelet aspect ratio.

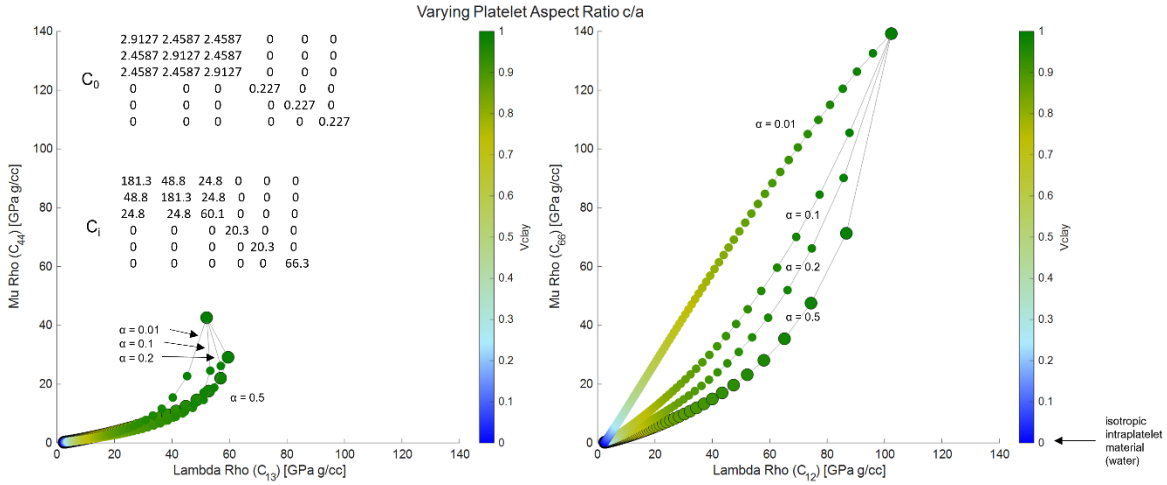


Figure 2. Pseudo LMR representation of shale. C_0 and C_i represent the matrix and inclusion stiffness tensor while each curve illustrates the impact of platelet aspect ratio.

Figure 3 below shows the combined LMR template between a quartz and shale mixture. The quartz trend comes from a Hertz-Mindlin Hashin Shtrikman granular model (Bachrach and Avseth, 2008). The trends are created by combining different amounts of quartz porosity with different amounts of clay bound water shale. The amount of clay bound water can be calibrated to match dipole measurements to construct a fit for purpose template.

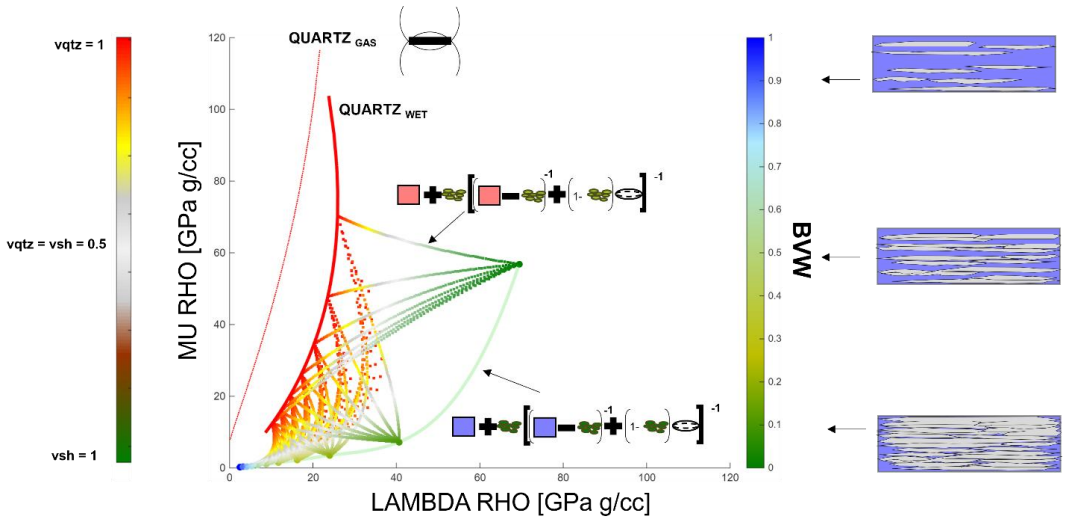


Figure 3. Combined LMR template for a quartz shale mixture.

Acknowledgements

Thanks to Colin Sayers for helpful discussion.

References

Bachrach, Ran and Avseth, Per; Rock physics modeling of unconsolidated sands: Accounting for nonuniform contacts and heterogeneous stress fields in the effective media approximation with applications to hydrocarbon exploration. Geophysics 2008; 73 (6): E197–E209. doi: https://doi.org/10.1190/1.2985821

Sayers, C. M., 2013, The effect of kerogen on the elastic anisotropy of organic-rich shales: Geophysics, 78, no. 2, D65–D74, http://dx.doi.org/10.1190/geo2012-0309.1.

Sayers, C. M., & den Boer, L. D. (2018). The elastic properties of clay in shales. Journal of Geophysical Research: Solid Earth, 123, 5965–5974. https://doi.org/ 10.1029/2018JB015600

Sevostianov, I., Yilmaz, N., Kushch, V., & Levin, V. (2005). Effective elastic properties of matrix composites with transversely-isotropic phases. International Journal of Solids and Structures, 42(2), 455–476. https://doi.org/10.1016/j.ijsolstr.2004.06.047