Multi-Attribute Rotation Scheme (MARS) – A tool for reservoir property prediction from seismic inversion attributes

Pedro Alvarez & Francisco Bolivar

A common way to understand the relationship between seismic attributes and petrophysical properties is by the use of rock physics templates (Ødegard and Avseth, 2004) or simply by cross-plotting well log derived elastic attributes against a color-coded petrophysical property. Both ways graphically illustrate the relationship between the elastic and petrophysical domains, which can be used to estimate reservoir properties from seismic inversion attributes. The multi-attribute rotation scheme (MARS) is a methodology that uses a numerical solution to estimate a mathematical expression that reproduces the aforementioned phenomena. This methodology uses measured and/or rock physics-modelled well log information, as an input, to estimate a well log-derived transform between several elastic attributes and the target petrophysical properties. The final goal of this workflow is to apply the resultant transform to seismically-derived elastic attributes to predict the spatial distribution of petrophysical reservoir properties for reservoir characterization and delineation, and/or to estimate secondary variables in geostatistical workflows for static model generation and reserve estimation.

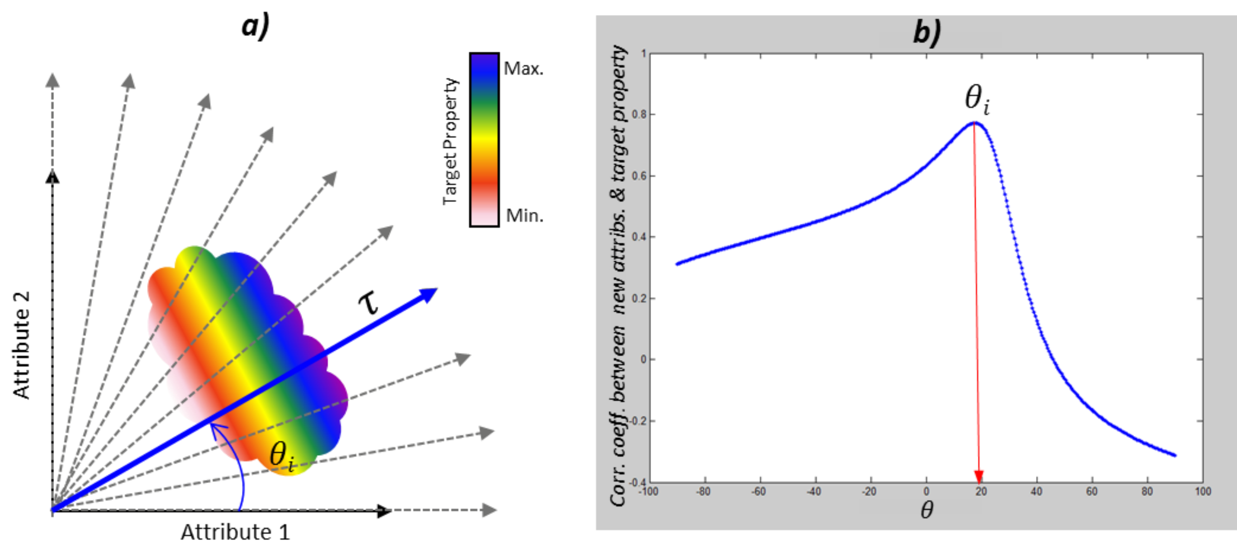

Figure 1. *a) Sketch of a cross-plot of two attributes color-coded by a target property. Dashed grey lines represent new attributes estimated via axis rotation, and the blue line represents the attribute that shows the maximum correlation coefficient with the target property. b) Example of a cross-plot between the angles of rotation and the correlation coefficients calculated at each of these angles.*

MARS estimates a new attribute τ in the direction of maximum change of a target property in an n-dimensional Euclidean space formed by n-number of attributes. We search for the maximum correlation between the target property and all of the possible attributes that can be estimated via an axis rotation of the basis that forms the aforementioned space. Figure 1a shows a sketch illustrating an example for the particular case of two dimensions. This methodology evaluates the relationship between all possible elastic attributes spaces and a target petrophysical property using a similar correlation approach to the one used by Whitcombe et al. (2002) in the Extended Elastic Impedance methodology (Figure 1b).

Case Study: Onshore Colombia

For this case study, MARS was used to estimate a Sw volume using a two-dimensional approach in a mud-rich turbidite gas reservoir, of early and middle Miocene age, located onshore Colombia. The global maximum correlation between the attribute τ and Sw was found in the $\sqrt{Is}$ vs $1/\sigma$ attribute space at -19 degrees, with a correlation of -0.9625. Figures 2a show a comparison between the actual and predicted Sw upscaled to seismic resolution, showing an excellent match between both curves. Finally the resultant transform was applied to seismically-derived volumes of $\sqrt{Is}$ and $1/\sigma$ to obtain a volume of Sw. A cross-section of the resultant Sw volume along Well-A and Well-B (blind test, see Figure 2b) along with its Sw curves are shown in Figure 2c. In this figure it is possible to see a good match between the seismic and well-log derived Sw, not only at Well-A, which was used in the MARS assessment, but also at Well-B, which was used as a blind test location.

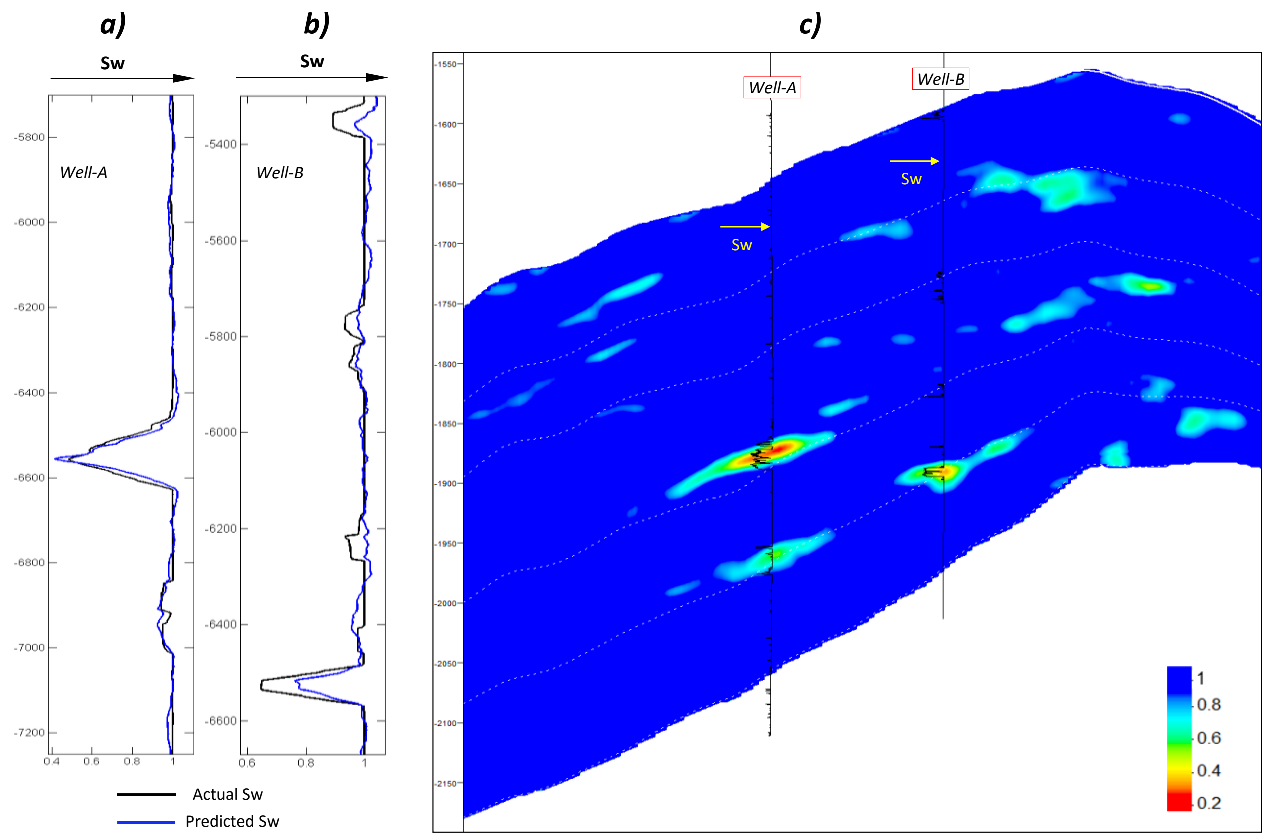

Figure 2. *a) For well A, comparison between the actual and predicted Sw logs upscaled to seismic resolution. b) For well B (blind test), comparison between the actual and predicted Sw logs, upscaled to seismic resolution, estimated using the transform computed for well A. c) Cross section along the resultant Sw volume along wells A and B (blind well) together with the Sw logs. Notice the good match between the seismic and well-log-derived Sw.*