Seismic Determination of Dolomitization and Associated Reservoir Quality Using Supervised Machine Learning Techniques: Lower-Middle Permian Carbonates of the Midland Basin

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Abstract

Extensive dolomitization is prevalent in platform and periplatform carbonates in the Lower-Middle Permian strata in the Midland and greater Permian basin. Early workers have found that the platform and shelf-top carbonates were dolomitized while slope and basinal carbonates were remained calcitic, proposing a Reflux Dolomitization Model as the possible diagenetic mechanism. More importantly, they underline that this dolomitization pattern controls the porosity and forms an updip seal. When applied to the Lower-Middle Permian dolomites in the Midland Basin, these studies are predominately conducted using well log, cores and outcrops, and while exhibiting high resolution vertically, such determinations are laterally sparse, inhibiting regional mapping. This investigation employs Supervised Bayesian Classification and Probabilistic Neural Networks (PNN) on 3D seismic in order to create an estimation of the most probable distribution of dolomite and limestone within a subsurface 3D volume petrophysically constrained. Combining this lithologic information with porosity we then illuminate the diagenetic effects on a seismic scale. Workflow commences with deriving lithology classifications from well log cross-plots of Neutron Porosity and Acoustic Impedance to determine a priori proportions of lithologies, and Probability Density Functions (PDF) calculation for each lithology type. These probability distributions and a priori proportions are then applied to full seismic volumes of acoustic impedance and predicted NPHI

volumes in order to create a lithology volume and their probabilities. Results suggest do support a regional Reflux Dolomitization Model, in which the porosity is increasing from shelf to slope while dolomitization is decreasing. However, when a seismic stratigraphic framework is employed, another possibility is that of an Oscillating Sea Level Dorag Dolomitization Model. With the overprint of subsequent mixing zones during sea level change, porosity destroying dolomitization would be maximally concentrated in the updip region. However, more work is needed to better identify the most appropriate model of dolomitization in these Lower to Middle Permian strata. In any case, these results demonstrate that diagenesis and corresponding reservoir quality in these platform and periplatform strata can be directly imaged and mapped on a seismic scale by quantitative seismic interpretation and supervised machine learning methods.