A Bayesian Inference Approach to Map Depositional Facies using Pre Stack Inversion

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Abstract

In the Arabian Peninsula, A clastic formation was deposited in multiple environments and has a very complex stratigraphy. Each depositional facies has different fluid flow properties, which creates barriers, baffles and conduits. Furthermore, each facies has different capacities for hydrocarbon storage. The identification and mapping of these facies help with the characterization of the lateral and vertical connectivity of the reservoir. This study aims to map depositional facies within the formation of interest using pre-stack seismic inversion. Pre-stack inversion of P-impedance and Vp/Vs ratio can be used to predict lithological facies or fluid content within the reservoir. However, pre-stack inversion offers a deterministic solution that does not address uncertainties with respect to the overlap of facies in the elastic domain. As an alternative, Bayesian inference can be utilized to indicate the likelihood of a given facies occurring at a position within a seismic grid, thus providing probabilistic solutions. In this study, pre-stack inversion was applied to an area with an abundance of wells with cores and with conditioned pre-stack seismic data. To apply Bayesian Inference, different depositional environment facies such as dunes, interdunes and playas were defined from well cores and then they were upscaled to the seismic resolution. In addition, core facies with similar reservoir properties were lumped in one label to improve the separation of facies in the elastic domain. After finding an acceptable relationship between the cores and the elastic logs, Bayesian inference can be used to model the facies in the elastic domain as probability density functions (PDFs). Afterwards, prior probability of each facies is estimated from geological information such as relative proportions of the facies at each well location. Finally, an estimate of the facies probability of occurrence are computed from combining the priori geological information with the PDFs and applying them at each voxel of the inverted P-impedance and Vp/Vs volumes. The results showed that the facies probability volumes can provide great understanding of the formation stratigraphy and depositional architecture in the area. Thus, ultimately helping in proposing new well locations and reducing the risk by providing a quantification of uncertainty associated with the new location.