Estimating Carbonate Reservoir Quality Using Rock Physics Templates

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The observed scatter of acoustic velocities of carbonate rocks with similar porosity, lithology and pore fluid can mainly be attributed to the complex pore structure of such rocks. The diagenetic processes of carbonates strongly differ from those of siliciclastic rocks. Carbonates can undergo several stages during diagenesis where reduction in porosity mainly occurs through cementation and compaction, while enlargement of the porosity mainly occurs by dissolution. The mineral can alter from aragonite to calcite which may be further dolomitized. Carbonate reservoirs are also exposed to fracturing. All this makes it a challenge to find a method for quantifying the porosity, lithology, and pore fluid from seismic data of carbonate reservoirs. Rock Physics Templates (RPTs), which have shown to be a powerful tool for relating seismic parameters to reservoir qualities for siliciclastic rocks, may potentially be a tool for carbonate rocks. However, due to the different origins of carbonates and siliciclastic rocks, carbonate RPTs should include effects honouring the attributes which are characteristic for such rocks. Among these are effects of porosity on several scales, complex pore structure, cementation, dissolution, fractures and anisotropy. In our attempt to construct RPTs for carbonate rocks we have used a visco-elastic effective medium theory where lithology, frequency, multiple porosity systems on various scales, cracks, fractures and diagenetic effects such as cementation and dissolution are considered. Cementation is modelled as infill of cement in the pores where we consider the cement to precipitate around the pore walls as spheroid shells characterized by an aspect ratio. By doing this we are able to study how the different distributions of cement in the pores are affecting the acoustic properties of the rock. By considering a rock physics model which opens up for the inclusion of the wide range of effects which may be significant for carbonate rocks, we are able to delineate such effects in their RPTs. Thus, from the RPTs it is possible to couple the seismic response to the carbonate reservoir qualities. In this paper we address the strategies behind the choice of rock physics modelling for the relevant carbonate RPTs, and the sensitivity of the acoustic attributes of various scenarios of carbonates reservoirs. The main focus in this analysis is to demonstrate how to construct and use carbonate RPTs in reservoir characterization and monitoring.