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Well Log Data Conditioning Using A Rock Physics Modeling Approach: Examples from the Banyu Urip Field, East Java Basin

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Abstract

Establishing decent seismic/well ties is crucial for quantitative geophysical applications such as seismic attribute analysis, seismic inversion, Amplitude Versus Offset (AVO) analysis, 4D seismic monitoring, and interpretation of multi-component seismic data. Well logs, particularly sonic and density logs, tend to be problematic in carbonate environments for a variety of reasons that include invasion effects and bad borehole conditions. In this paper we propose the use of a robust and practical carbonate rock physics model to address various log quality issues in a predictive manner. The predictive power of this carbonate model has been demonstrated through significant improvements in well-seismic ties for 4 wells from the Banyu Urip field in Mobil Cepu Ltd.'s Cepu Kontrak Kerjasama (KKS), East Java Basin.

Resistivity log data (deep, shallow, and micro resistivity) from Banyu Urip wells show strong mud filtrate invasion within the carbonate reservoir section in comparison with the overlying clastic section. While invasion effects on density logs is well known, our quantitative data analysis shows that the fluid invasion effect on sonic logs is strong enough to impact the quality of Banyu Urip well-seismic ties. For instance, our rock physics model gave a much better prediction of measured shear-wave (or S-wave) logs (and hence the compressional to shear velocity ratio or Vp/Vs) when assuming 100% mud filtrate invasion, indicating that sonic log tools measure within the invaded zone of the carbonate section. Pronounced invasion effects on sonic and density logs are also seen in the shallow gas-bearing clastic section that overlies the Banyu Urip carbonate reservoir. Logs in the clastic section are also affected by washout, and by anisotropy where boreholes are highly deviated. Significant improvements in seismic/well ties were achieved following editing of measured well log data. These improved well ties will be used for a variety of quantitative geophysical applications that hitherto have been challenged due to seismic and well log data quality issues.

Introduction

Carbonate reservoirs (limestone and dolomite) account for approximately 50% of oil and gas production worldwide. However, seismic responses in carbonate rocks are poorly understood. For example, it is not known if conventional Direct Hydrocarbon Indicator (or DHI) ranking and AVO classification systems developed for clastic rocks are applicable to carbonate rocks. An accurate and physically sound carbonate rock physics model is needed to address these technical issues. Development of a carbonate rock physics model is extremely difficult because carbonate rocks generally have more complex pore systems than do clastic rocks. While clastic rocks have mainly intergranular pores, carbonate rocks can have a variety of pore types such as moldic, vuggy, interparticle, and intraparticle. In additional, diagenesis often plays a significant role in the alteration of depositional carbonate pore systems. Recent published studies show that carbonate pore type strongly affects the porosity-velocity relationship (e.g., Eberli et al. 2003). The complex, multi-scale pore system in carbonates leads some authors to question the validity of fluid substitution calculations using the Gassmann equation (e.g., Wang 1997, Baechle et al. 2005), while others claim that the Gassmann approach (1951) works perfectly fine (e.g., Rasolofosaon 2006, Adam et al. 2006). It is important to understand why the Gassmann approach appears to work for carbonate rocks in some cases but not in