

SP4

Study on the Effect of Fluids in Acoustic Frequency Response of Carbonate Rock Samples

A. Almarashda* (Petroleum Institute)

Summary

Carbonate formations constitute more than 50% of the global hydrocarbon reserves and great amount of aquifers. Carbonate systems exhibits complexities where many challenges face geophysicists and geologists when attempting to define carbonate formations from seismic data. Part of these challenges are related to the interaction between the pore fluid and rock constituents which affected the elastic properties of a rock. On the other hand, seismic is one of the methods that have been widely utilized in the petroleum industry and engineering investigations as it plays a major role in mapping subsurface geology and structures. However, the relation between acoustic frequency and rock properties is still not well understood. The present project attempts to investigate the effect of fluids (oil and water) in the acoustic frequency response in four carbonate samples. The accomplishment of this objective will assist to understand in a small scale the effect of fluids in rocks to latter be applied in the interpretation of field scale formation. In an approach to determine both shear and compressional waves through each core sample at dry and fully saturated conditions, a simple circuit have been assembled including acoustic transducers, oscilloscope and pulser-recevier. To measure the compressional wave (P-wave) a pair of 1 MHz transducers have been used whereas for the two perpendicular shear waves (S1 and S2 waves) two pairs of 0.5 MHz transducers were utilized. The waveforms attained were processed in MATLAB software to evaluate the frequency response for each core sample at different conditions (dry, full water saturation and full oil saturation) by applying the Fast Fourier Transform (FFT) principle. In addition, the corresponding travel times in each sample and condition were measured.

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The experimental results reveals that the used samples have various main frequency responses for the P-waves that are independent of the saturation, lies between $2.44\text{E}+04$ MHz to $1.95\text{E}+05$ MHz. Whereas, shear waves shows distinctive results that differ the dry state with a value of $4.88\text{E}+04$ MHz from the saturated state (oil and water) with $3.91\text{E}+05$ MHz. These results suggests that shear waves could also assist to differentiate carbonate gas zones. In addition, our preliminary analysis shows that the main frequency response for P-waves are influenced by porosity and permeability as shown in Figure 1. At dry conditions, the P-wave main frequency response decreases with porosity and increases with permeability. At water and oil saturation, the P-wave main frequency and porosity trends are fluctuating and opposite to each other. Moreover, P-wave main frequency and permeability trend for water saturation is clearly exponential and almost the inverse for oil saturation. It can be seen that porosity and permeability have an opposite effect.

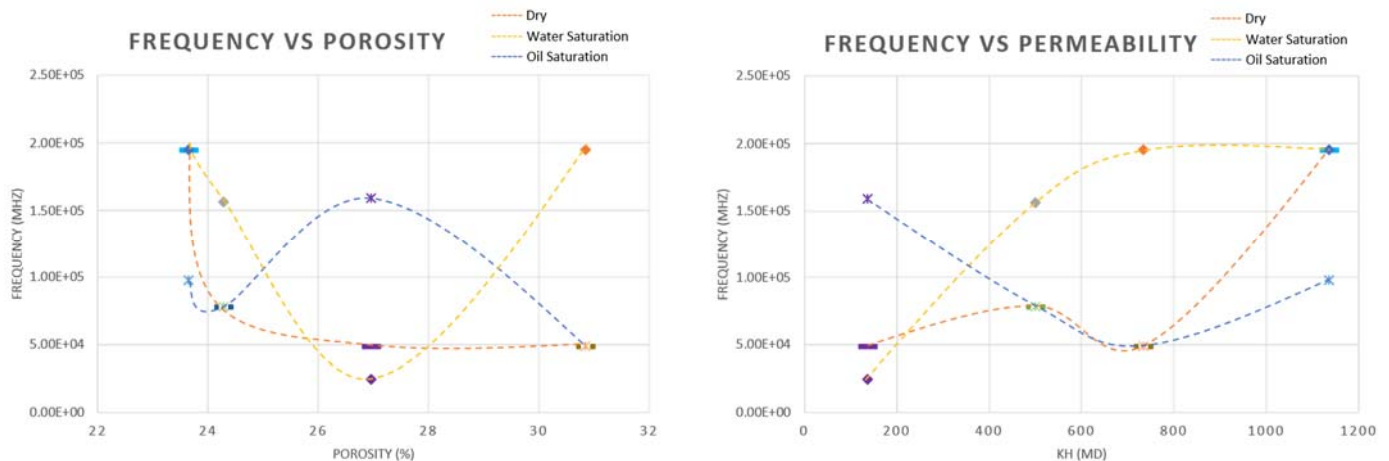


Figure 1 P-wave main frequency results in relation to porosity and permeability.

In conclusion, we can say that there is a strong indication that porosity and permeability play an important role in the P-wave main frequency response of these carbonate rocks. Consequently, P-wave frequency combined with the effect of porosity and permeability may be used as an indicator of different type of fluid saturations. Finally, S-waves show a more clear response in frequency by itself than P-wave to distinguish oil/water saturation from dry.