ACOUSTIC CORE ANALYSIS IN RESERVOIR APPRAISAL

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Abstract Acoustic velocity measurements from core samples can play an important role in correlating seismic velocities to underlying reservoir properties. Seismic velocity in reservoir rocks is most directly affected by lithology, porosity, confining pressure, and pore saturant. Unfortunately, the relationship between velocity and each of these variables is non-unique. This uncertainty limits the geophysicist's ability to map reservoir properties from seismic data and complicates the use of sonic logs in petrophysical analysis. Laboratory experiments provide a controlled environment where the relationships between acoustic velocity and petrophysical parameters can be independently studied.

We have recently completed a research project focusing on the acoustic properties of carbonate cores. Laboratory experiments were designed to measure the acoustic velocity sensitivity to changes in porosity, net confining pressure and pore saturant. As expected, porosity correlates negatively with acoustic velocity, with correlation coefficients of -0.72 in gas saturated samples, and -0.84 in oil saturated cores.

Increasing effective confining pressure from 6.9 to 34.5 MPa resulted in increases in compressional velocity from 2% to 35% in gas saturated cores, and 1% to 19% after oil saturation. Shear wave velocities were slightly less sensitive to pressure with maximum changes of 26 %, and 22% in gas and oil saturated cores respectively.

Velocity sensitivity to pore fluid saturation was highly variable in the carbonate samples tested. Saturating the gas-filled cores with a 35 degree API mineral oil caused compressional velocity increases from 2% to 35%. These velocity changes decreased with increasing confining pressure. Average saturation-induced velocity increases were 13% at 6.9 MPa, 7% at 20.7 MPa and 6% at 34.5 MPa. Differences between oil and water saturated compressional velocities were usually less than 3%. Shear wave velocities were not strongly affected by changes in pore fluid saturation, as predicted by theory.

Laboratory experiments provide a means to separate the inter-related effects of pressure, porosity, and pore fluid saturation in the velocity data. Porosity is well correlated to seismic velocity if saturations and rock type are constant. Predicting pore fluids from seismic data will be complicated by the different magnitudes of saturation sensitivity among carbonate rocks. A thorough understanding of the effects of these factors on acoustic velocity is needed to properly interpret seismic data for use in reservoir characterization and appraisal.