



## **Rock physical model to describe the acoustic hysteresis validated on laboratory measurements**

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Due to the increasing demand for hydrocarbons and the depletion of the known hydrocarbon fields there is a growing claim to predict rock physical parameters more accurate at non-conventional conditions also. It is well known that acoustic velocity in rocks strongly depends on pressure which influences the mechanical and elastic properties of rocks. The wave propagation under pressure is very nonlinear and the elastic properties of rocks are hysteretic. Characterization of hysteretic behavior is important for mechanical understanding of reservoirs during depletion.

The idea that the pressure-acoustic velocity connection can be characterized by exponential function is well-known but the developed empirical models are based on mathematical curve fitting, however the physical meaning is partly understood. We developed a new quantitative petrophysical model describing the acoustic hysteresis which provides the previously mentioned connection both in case of pressurization and depressurization periods. The advantage of the model is that it is not based on simple curve fitting, but gives physical explanation for the process with three-parameter exponential equations. After Birch we assume that the main factor determining the pressure dependence is the closure of pores. Since the base of the model is the change of pore volume (which is independent of the direction of loading) it can be applied also in case of S waves. Based on the model the acoustic hysteresis can be expressed by two different parameters because the closed pores do not reopen entirely during depressurization. The model is valid only in reversible/elastic range.

To confirm the reliability of the model it was applied to acoustic velocity data measured on sandstone samples by an automatic acoustic test system. By means of joint inversion-based data processing, the model parameters were determined from measurement data. Calculated data could be produced by using the petrophysical model and a very good fit between measured and calculated data (in case of P and S waves too) was found thus inversion results confirmed the accuracy and feasibility of the petrophysical model.

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**Keywords:** rock physical model; acoustic hysteresis; pressure; acoustic P and S wave velocities; laboratory measurements