Geophysical Research Abstracts
Vol. 19, EGU2017-8758, 2017
EGU General Assembly 2017

Comparison of static and dynamic properties in a shale rock

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When trying to understand the elastic properties of rocks in order to ultimately compare laboratory and field data, two opposite measuring techniques can be used: the “static” and “dynamic” measurement techniques. The “static” measurement technique consists in characterising the medium by its strain response to an applied stress. The strain rate is generally low enough that the measurement can be addressed as static. Using ultrasonic wave velocity, the “dynamic” measurements are obtained. Those allow obtaining accurately the full set of elastic constants characterising the medium. However, such measuring procedure is at high frequency, implying the risk for dispersion and attenuation effects to occur.

When comparing the “static” and “dynamic” measurements, and investigating their differences, the effect of the measuring frequency is often the parameter considered. However, it is not the only parameter that may play a role. Indeed, often, “static” measurements rely on strain amplitudes above 10-4. On the other hand, “dynamic” measurements rely on strain amplitudes below 10-6. Such difference may play an important role in comparing measurements in weak materials such as shales. For this particular rock, the effect of strain amplitude on the “static” measurements is investigated by decreasing the amplitude of stress variations.

Moreover, due to both multiscale and sedimentary nature, shale materials can exhibit strong anisotropic properties, usually described as transversly isotropic. In this study we propose to compare the different ways of measuring elastic moduli of Tournemire shale (IRSN underground laboratory, Aveyron, Southern France).

In a first part, static moduli were calculated on three sets of samples with different bedding orientations (90°, 0°, 45°) deformed under deviatoric pressure at different confining pressures (2.5, 5, 10, 20, 40, 80MPa). During these deformation experiments, elastic wave velocities were continuously measured along different raypaths allowing to determine the dynamic elastic properties. Finally, hydrostatic loading experiments on the three orientations were done with steps of axial deviatoric pressure inducing a deformation of the order of 10-5.