High resolution spatial and temporal laboratory seismic datasets by Laser Doppler Vibrometry
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Research context & objectives

We propose to perform sub-meter scale seismic measurements with innovative experimental tools in a laboratory environment which reproduces large-scale field explorations in well-conditioned and controlled environment. The purpose is to develop high resolution seismic methods on various natural samples, that can be transferred later to large-scale field conditions. Seismic waves are produced in our experiments by a P-wave piezoelectric transducer stuck to the sample surface. Nanometer mechanical displacements induced by the transducer are measured by LDV around the middle section of the core. Measurements close to the sources are not reliable because of instrumentation defects. The wavefield is recorded on a flat sensor in space due to the heterogeneities inside the natural rock. We can still recognize the P wavefield and S wavefield, including areal leakage of the noise due to the core and also these two sources.

Conclusion:

The excellent agreement between experiments and simulations demonstrates that the full wavefield is nicely recorded by the single point LDV, which validates our numerical scheme and models. A first qualitative analysis of the multidimensional dataset confirmed the data quality and the capability of the full-field 3D scanning vibrometer. We can then perform basic time-lapse tomography in order to get a first insight of the elastic wave velocity models for the carbonate core. Further analyses on simulated and experimental multidimensional data will enable us to look quantitatively into the polarizations and quantify the Amplitude vs Angle (AVA) influence on the surface measurements. Seismic attributes such as amplitudes and frequencies contain also rich information on other rock physics properties including quality factor, anisotropy and porosity etc. [2,3]. The full-field data can eventually be used to test Full Waveform Inversion schemes which would in turn yield more reliable and accurate inversion results.

References

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LDV and geophysical applications

Multidimensional measurements

Application on carbonate core