Development of Small Triaxial Cell For Combine STATIC & DYNAMIC Near Surface Rock Physics

Jalal Khazanehdari & David Mainprice

Laboratoire de Tectonophysique, Universite Montpellier II, Place Eugene Bataillon, 34095 MONTPELLIER Cedex 05, France.

khazaneh@dstu.univ-montp2.fr   david@dstu.univ-montp2.fr

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1. Introduction

Near surface rock characterisation has important applications in many areas of geosciences such as hydrogeology, petroleum exploration, nuclear waste disposal & geothermal energy. Successful characterisation can be achieved if laboratory measurements, which are essential for understanding the inter-relationships between physical, mechanical and fluid flow properties of rocks (e.g. acoustic, electrical porosity & permeability) are carried out under *in situ* conditions. With these aims, a traxial deformation machine has been developed for 25 mm rock cores. The described apparatus is used for combine acoustic velocity, attenuation and stress-strain volume measurements, over wide ranges of differential and pore-fluid pressures on sandstone samples.

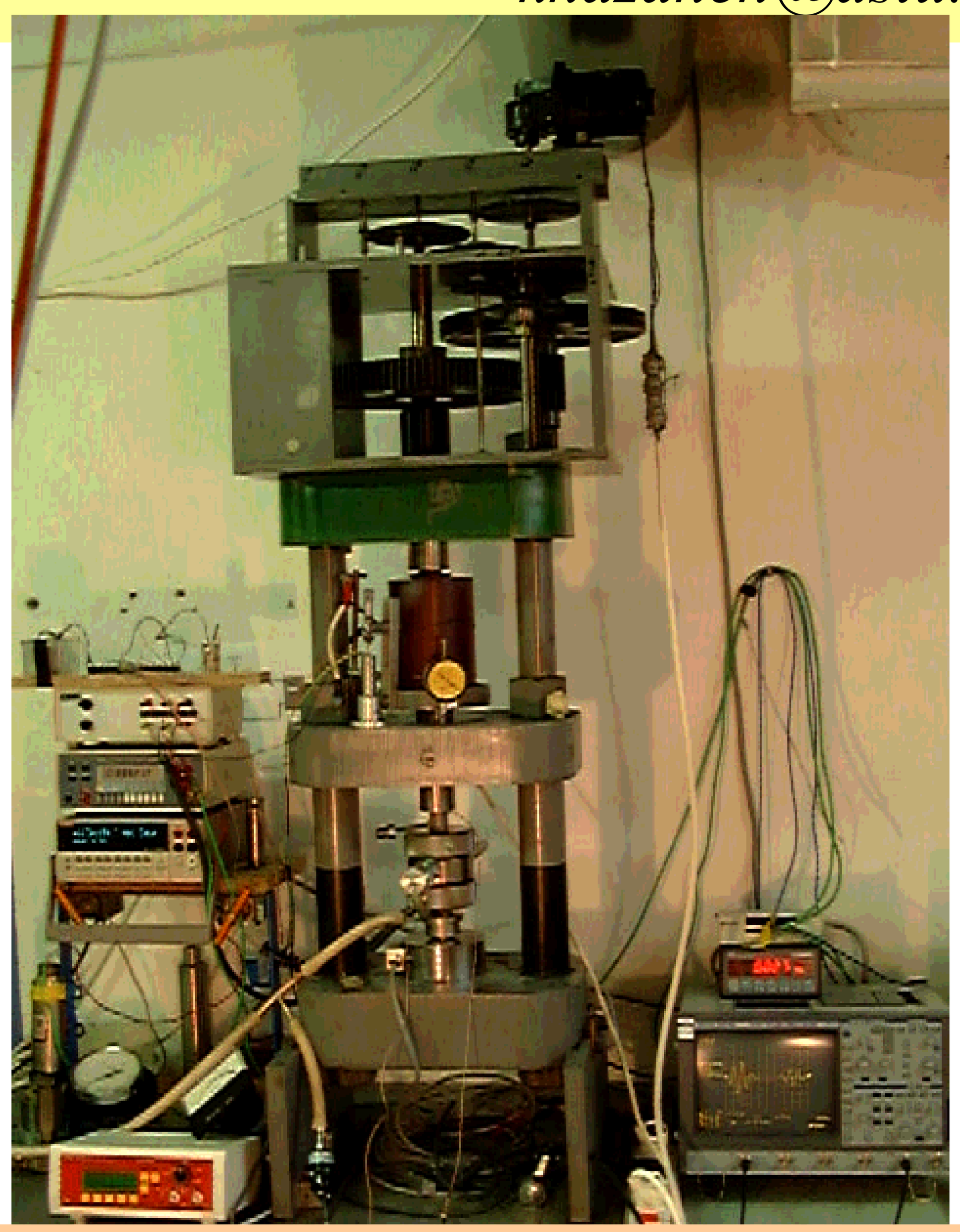
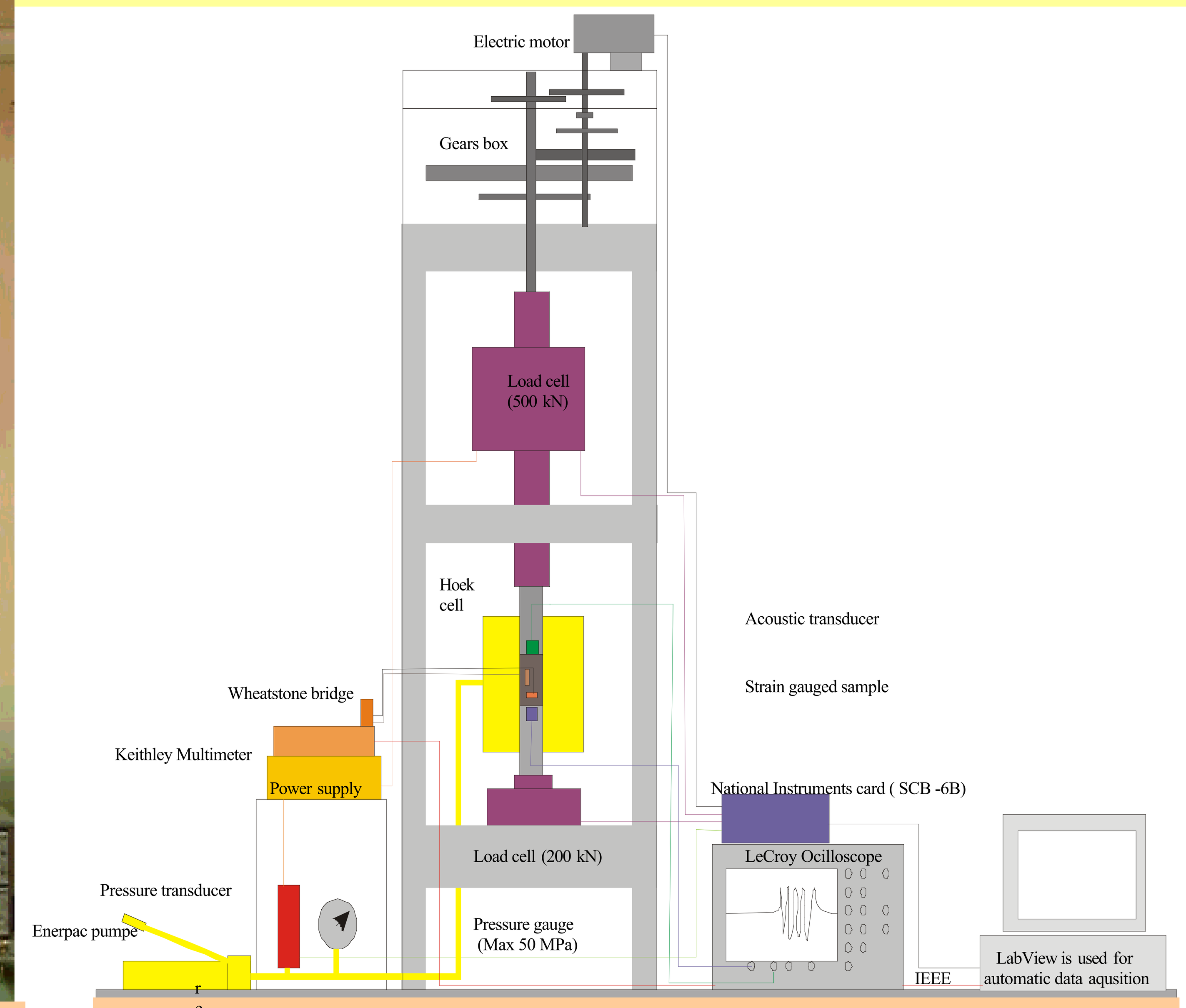
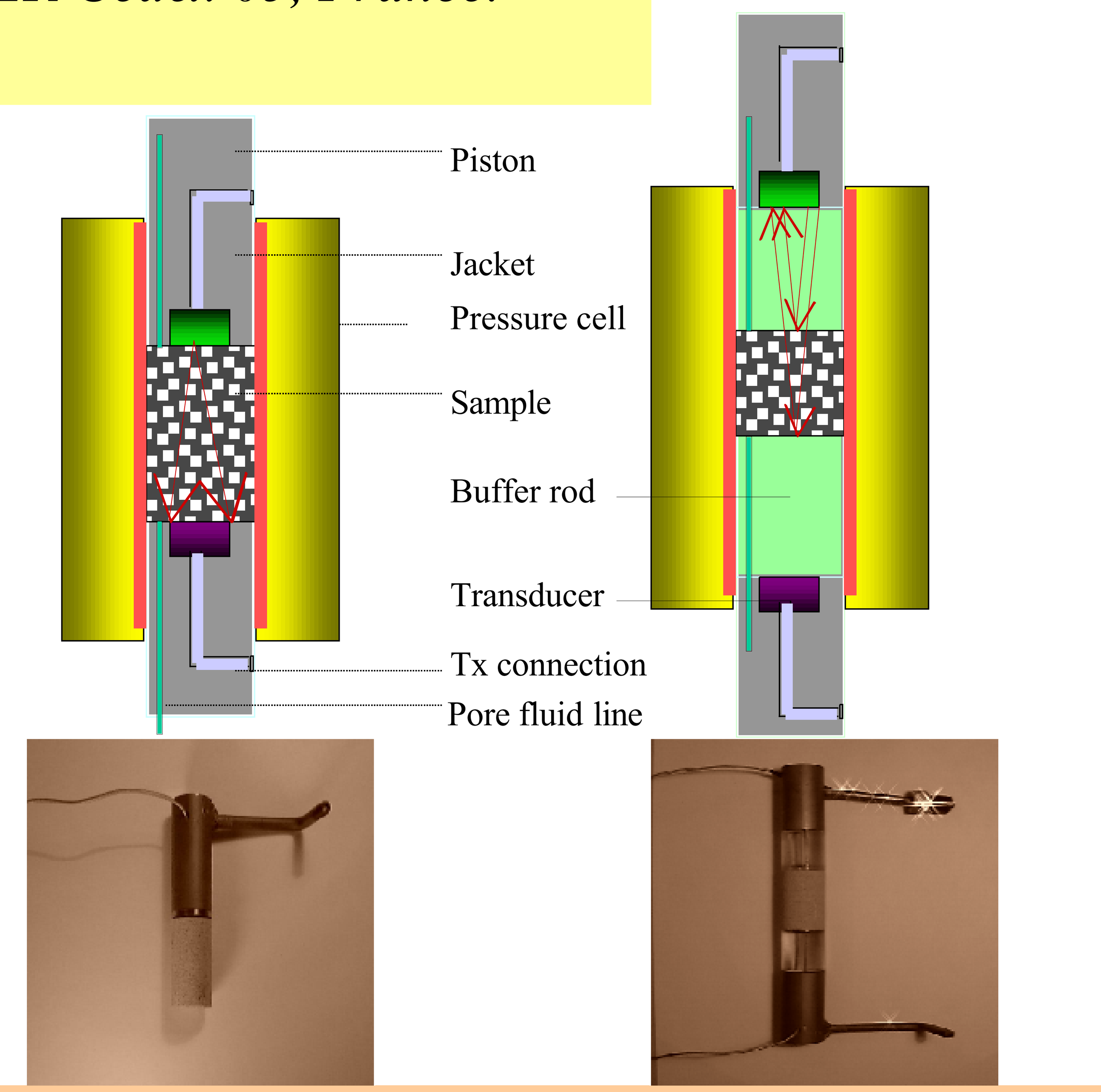


Photo of Traxial apparatus and the measuring instruments.



Schematic drawing of the traxial apparatus and measuring instruments.

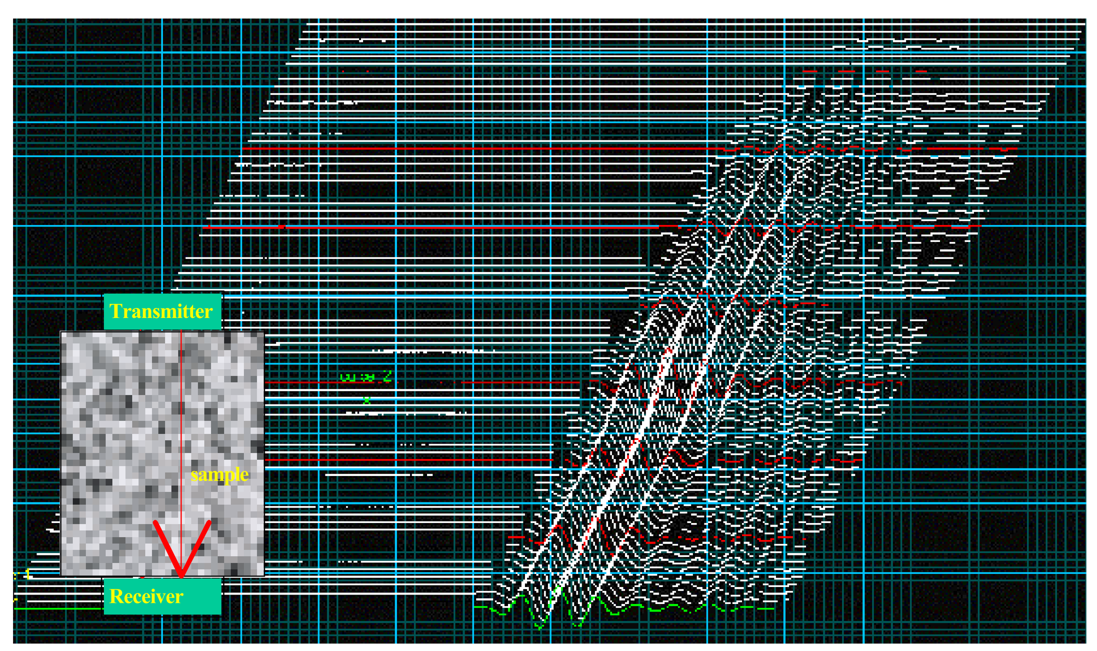


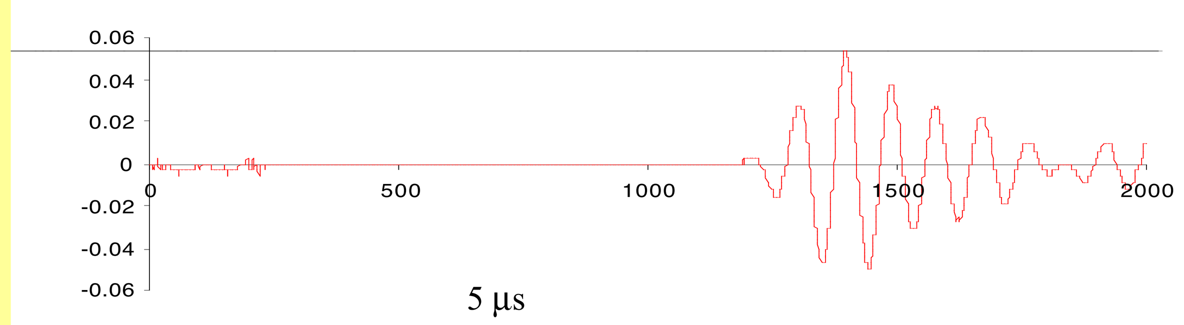
Drawing of the sample, transducer assembly for pulse transmition (top, left) and pulse echo (top, right) techniques. The photos show the steel pistons housing the transducers and the pore fluid line and the wire connections.

Measurements of ultrasonic velocity can be carried out using both pulse-echo (Winkler and Polona, 1982) and pulse transmission (Birtch, 1960) techniques. Calibration tests show that the ultrasonic measurements have an accuracy of ± 3% for velocity and 0.1 dB/cm for the attenuation, the later corresponding to ± 5 for a quality factor of 50.

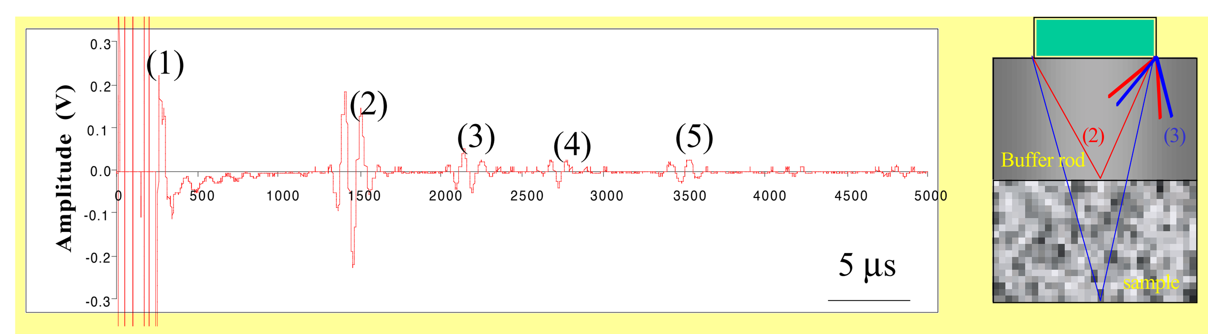
2. Experimental Acoustic Setup

The pressure cell is based on design develop by Hoek. The maximum confining pressure is limited to 350 bars, which is sufficient for near surface applications. The axial load can be changed independently therefore providing a wide ranges of differential stresses. In addition, a high-pressure pump provides the necessary pore fluid pressure (Max. 300 bars). The axial pistons have pore fluid connections and housing ultrasonic transducers. The acoustic system consist of a tone burst pulser, pair of compressional and shear transducers with wide dynamic ranges and digital oscilloscope. The samples are strain gauged for volumetric strain measurements.

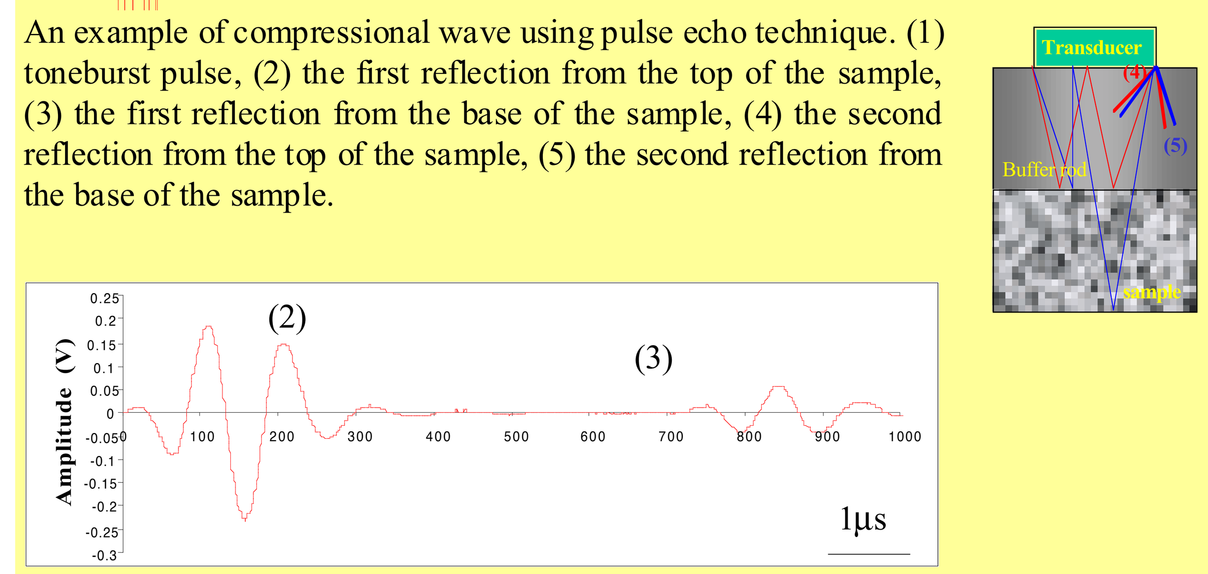




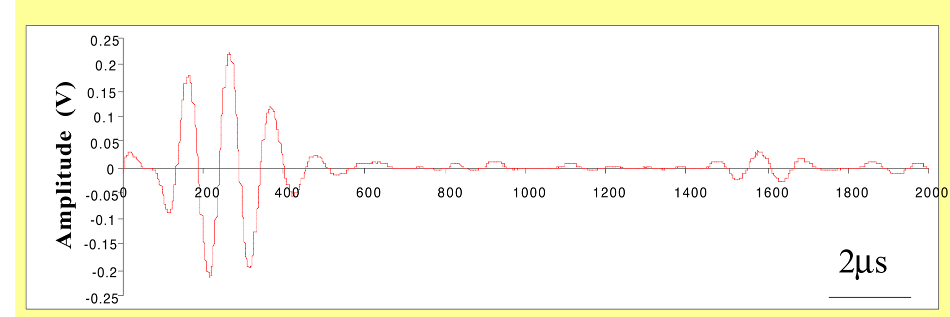
An example of acoustic measurements during a Triaxial test. For this type of experiment, the axial load is increased at a constant rate, while Radial stress was kept constant. The acoustic attributes (Vp, Qp) can be measured continuously during loading; above figure is a seismogram of the measured compressional waves during a triaxial loading experiments. Seismic traces recorded at every one-minute during a triaxial test on a Limestone sample. The confining pressure was 2 MPa and the maximum axial load was 82 MPa.



An example of compressional wave using pulse echo technique. (1) toneburst pulse, (2) the first reflection from the top of the sample, (3) the first reflection from the base of the sample, (4) the second reflection from the top of the sample, (5) the second reflection from the base of the sample.



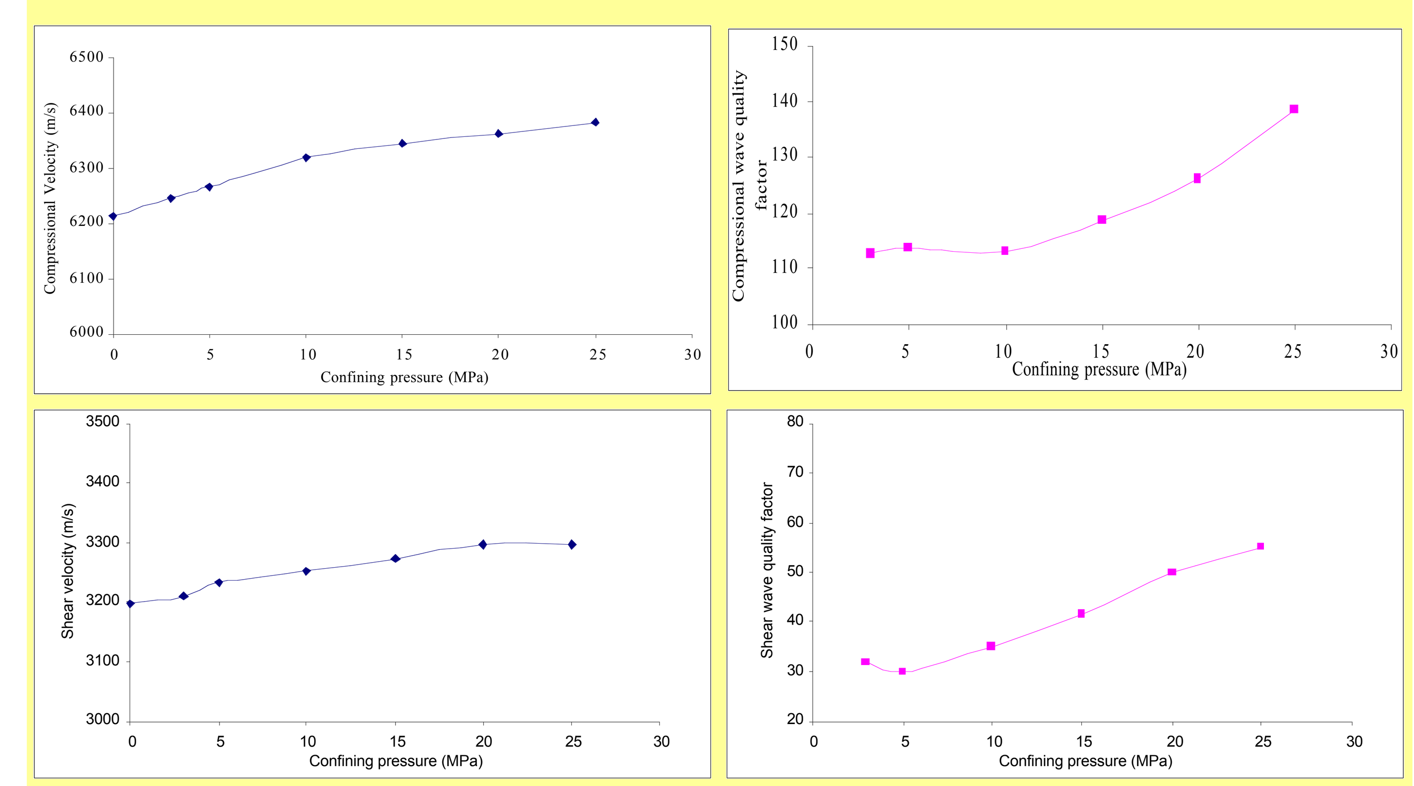
An example of Compressional waves top and bottom reflections using pulse echo technique.



Examples of shear waves top and bottom reflections using pulse echo technique.

3. Preliminary results

The compressional velocity and attenuation of a Carrara Marble sample were measured under fully-saturated condition as a function of confining pressure with the aim to investigate the pressure sensitivity of micro-fractures.



Top: plot of compressional wave velocity and quality factor as a function of confining pressure fore a fully saturated sample of Carrara Marble.
Bottom: Plot of shear wave velocity and quality factor as a function of confining pressure fore a fully saturated sample of Carrara Marble.

References:
(1) Birtch, F., 1960, The velocity of compressional waves in rocks to 10 kilobars, J. Geophys, Res, 65, 1082-1102.
(2) Winkler, K. W. and Polona, T. J., 1982, Technique for measuring ultrasonic velocity and attenuation spectra in rocks under pressure: J. Geophys. Res, 87, 1077-1078.

Acknowledgements:
We are grateful to Mr. Etienne. de Vautibault for his help with the construction of the acoustic apparatus. This work was supported through a Maria Currie research fellowship awarded by European Commission to J. Khazanehdari.