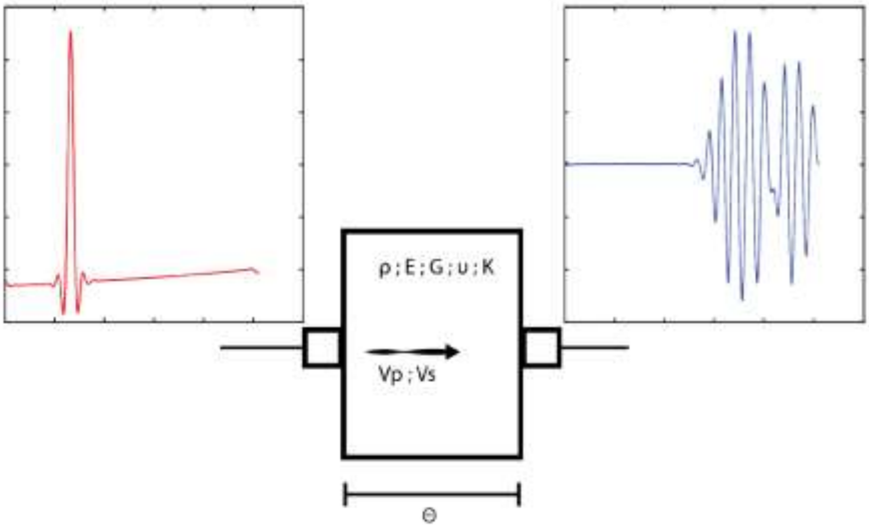
Seismic properties exercises

This exercise aims to show how, through seismic wave propagation on rock samples, it is possible to determine the elastic properties of the material.

Geometry of the experiment:

The geometry of the experiment is presented in the figure below. One transducer will pulse a 'trigger' waveform that will travel through the cylindrical specimen of diameter Φ for which only the bulk density ρ is known. On the other end, another transducer will receive the waveform (either Pwave or Swave) with a certain delay which will be directly related to the wave velocity.



The transducers consist in elements that convert electrical pulses into mechanical pulses and vice-versa. Piezoelectric elements were used in this example. A piezoelectric element contains ceramics or crystals whose vibrations will perform the conversion task.

The sampling frequency for the measurements used is 10 MHz.

Tested specimens

The experimental materials analysed are:

Sample	Berea Sandstone 1	Berea Sandstone 2	Berea Sandstone 3	Berea Sandstone 4	Berea Sandstone 5	Berea Sandstone 6
ρ (kg/m3)	2650	2650	2650	2650	2650	2650
Φ (mm)	37.5	37.5	37.5	37.5	37.5	37.5
Relative humidity (%)						

Sample	Fontainebleau Sandstone 1	Fontainebleau Sandstone 2	Fontainebleau Sandstone 3	Fontainebleau Sandstone 4	Fontainebleau Sandstone 5	Fontainebleau Sandstone 6
ρ (kg/m3)	2650	2650	2650	2650	2650	2650
Φ (mm)	29	29	29	29	29	29
Relative humidity (%)						

Sample	Unknown Sandstone	Unknown Limestone
ρ (kg/m3)	2650	2650
Φ (mm)	29	37,5
Relative humidity (%)	60	60

Picking and calculation:

(a) Picking arrival times: The Matlab code 'Picking' is designed to pick arrival times. To proceed:

- Launch MATLAB.
- Open the Picking.m file in the Exercise folder.
- Run the code.
- Follow the instructions in the command window.
- Once it is done, save the Data variable (right click -> save as)
- Proceed to calculations.

(b) Calculation: Calculate for each sample, the propagation velocities of the compression and shear waves, Vp and Vs respectively. For this, use the following notation: V = pulse propagation velocity (m/s), L = pulse-travel distance (m), T = effective pulse-travel time (s) (Arrival time to the receiver minus departure time of the trigger pulse). If the degree of velocity anisotropy is 2% or less, using only ρ = density of the material (kg/m3), calculate the following elastic constants:

- E = Young’s modulus of elasticity (Pa).
- ν = Poisson’s ratio.
- μ = modulus of rigidity or shear modulus(Pa).
- K = bulk modulus (Pa).
- λ=Lame's coefficient.
- M= Pwave modulus.

(c) Interpretation: For the Berea Sandstone and Fontainebleau Sandstone, the numbered tests were performed under different relative
humidity conditions. (5%; 23%; 43%; 60% (atmospheric humidity); 75% and 95%).
By plotting together all the traces try to complete the corresponding relative humidity in the material table. Explain.