Dynamic Measurements of the Mechanical Properties of Rocks

Geophysics 457
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Purpose:

The purpose of this experiment is to make direct measurements of the velocity of compressional and shear waves. This is done for various samples, and from them we can calculate elastic constants. This experiment also examines the effects of varying confining pressures on seismic waveforms and the elastic constants themselves.

Materials:

- Olympus 5077PR Ultrasonic Transmitter and Receiver
- Tektronix DPO3014 Digital oscilloscope
- Hydraulic press
- High accuracy 24 bit A/D data acquisition converter
- LoadVue acquisition
- Mass scale
- Calipers

Relevant Formulae:

$$V_P = \left(\frac{k + \frac{4}{3}\mu}{\rho} \right)^{1/2} = \left(\frac{E(1-\nu)}{\rho(1-2\nu)(1+\nu)} \right)^{1/2} \quad \text{and}$$

$$V_S = \left(\frac{\mu}{\rho} \right)^{1/2} = \left(\frac{E}{2\rho(1+\nu)} \right)^{1/2}$$

Procedure:

*Refer to lab manual

Analysis:

1. and 2. are on excel spreadsheet.

3. Graph on excel. Some of the trends we can see on the graphs is that generally as axial stress increases, the P wave and S wave velocity stay relatively linear. Obviously the S wave plot is lower than the P wave plot, because P wave velocity is always higher than S wave.

4. On excel.

5. For the belly river sample specifically, as we increases the load stress, the P wave velocity began to increase as well. The S wave velocity stayed relatively the same. For the Bereta sample similar pattern was observed for the S wave form, and P wave exhibited that a little bit as well.

As for direct relationships between the elastic constants, we know that μ depends entirely on S wave velocity. If S wave velocity goes up, so does that.

k is larger if P wave velocity is large, and smaller when μ is large.

E depends on S wave velocity and v, if those two are large, it is also large.

6. N/A since we did not use perpendicular fiber sample.

7. The only sample that was the same from last lab was the belly river. From looking at last labs values, they do not match at all with this labs. All the elastic constants are quite off, along with the P and S wave velocities. I feel like this lab values are more on the correct side because they match more closely with the textbook/literature values, as we can see in the table down below.

Lab 04

P wave velocity (m/s)	S wave Velocity (m/s)	P wave stress (Pa)	S wave stress (Pa)	μ	k	λ	v	E
3885.47486	2897.916667	589954.2812	483572.9387	22606783455	10497762099	-4573426870	-0.1268	39480276469
3896.358543	2897.916667	760874.7357	663971.9873	22606783455	10725756828	-4345432142	-0.11898	39834105019
3907.303371	2897.916667	941038.5835	930454.5455	22606783455	10955675557	-4115513413	-0.11128	40182083387
3907.303371	2897.916667	1124801.004	1124730.444	22606783455	10955675557	-4115513413	-0.11128	40182083387
3918.309859	2897.916667	1305364.693	1380628.964	22606783455	11187539997	-3883648973	-0.10371	40524351467

Lab 03

	E (N/m2)	v	P (kg/m^3)	k (MPa)	µ (MPa)	λ (MPa)	Vp (m/s)	Vs (m/s)
Bellyriver Sandstone	6.324 E9	0.3994	2628	2873	2260	1366	1497	927

Literature/Textbook Values

Coefficients for the equation $\rho_b = aV_P^2 + bV_P + c$

Castagna et al. 1993

Lithology	a	b	c	V_P range (km/s)
Shale	−0.0261	0.373	1.458	1.5–5.0
Sandstone	−0.0115	0.261	1.515	1.5–6.0
Limestone	−0.0296	0.461	0.963	3.5–6.4
Dolomite	−0.0235	0.390	1.242	4.5–7.1
Anhydrite	−0.0203	0.321	1.732	4.6–7.4