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Nonlinear elasticity in fault-zone and volcanic rocks

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The Physical Acoustics Lab has a 20-year history in studying both fundamental problems in wave propagation and applied research. The applied research has an emphasis on geophysics, where our experiments on rocks in the lab contribute to our understanding of geohazards including Whakaari, White Island and the Alpine Fault, New Zealand. More recently, our rock physics supports programmes in carbon and hydrogen geo-sequestration, as well as ventures in planetary geophysics. Beyond the geophysical applications, we have projects on non-destructive testing of fruit, ice, timber, and work on medical imaging. While this may appear as a widely varying set of problems, the underlying measurements have a common data acquisition system. In the physical acoustics lab we have developed a fully non-contacting laser ultrasonics setup, based on laser technology. We excite laser ultrasound with high-powered short-pulsed laser light, and detect the wavefield with laser Doppler vibrometry. The advantages of laser-based measurements over conventional contacting ultrasonic transducers include:

1. There is no mechanical ringing in the source or receiver.
2. There is no issue coupling source and receiver to the sample.
3. Source and receiver can be placed independently with computer-controlled motorized stages.
4. Source and receiver can access samples under hostile conditions, such as extreme temperatures and pressures.

Under this backdrop we have started a programme on nonlinear elasticity in the lab on different rock types. For these rocks, we investigate the elastic nonlinearity as a function of the temperatures and pressures experienced under in situ conditions.

In this presentation, we show laser-ultrasonic measurements on rocks from two of New Zealand's most prolific geologic features. First, we investigate the nonlinear elasticity of rocks in the damaged zone of the Alpine Fault of New Zealand's South Island. Second, we present similar measurements on rocks from Whakaari – White Island, off the coast of the North Island of New Zealand.

For both samples, we have monitored the nonlinear elastic behaviour as a function of the temperature and pressure conditions representative of those expected for these rocks buried near the surface. Finally, we will discuss not only the implications from these measurements, but speculate about the effects of fluids on the nonlinear elasticity of such rocks.

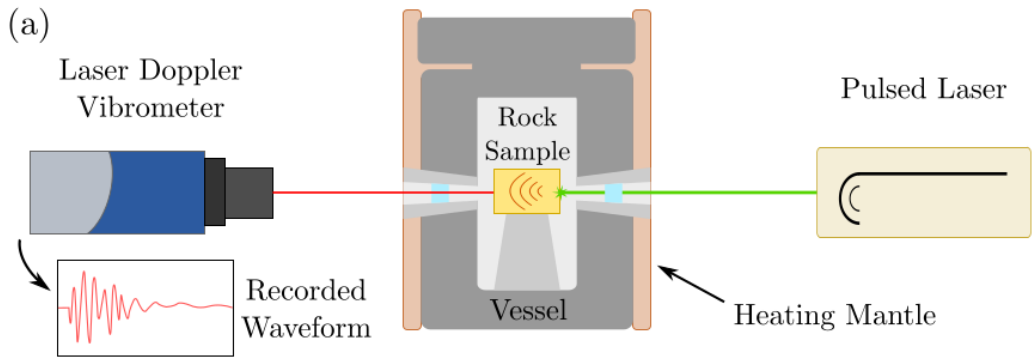

Figure 1: Experimental setup to measure the temperature and pressure dependency of elastic nonlinearity.

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