Towards Visualising Causes of Nonlinear Rock Physics

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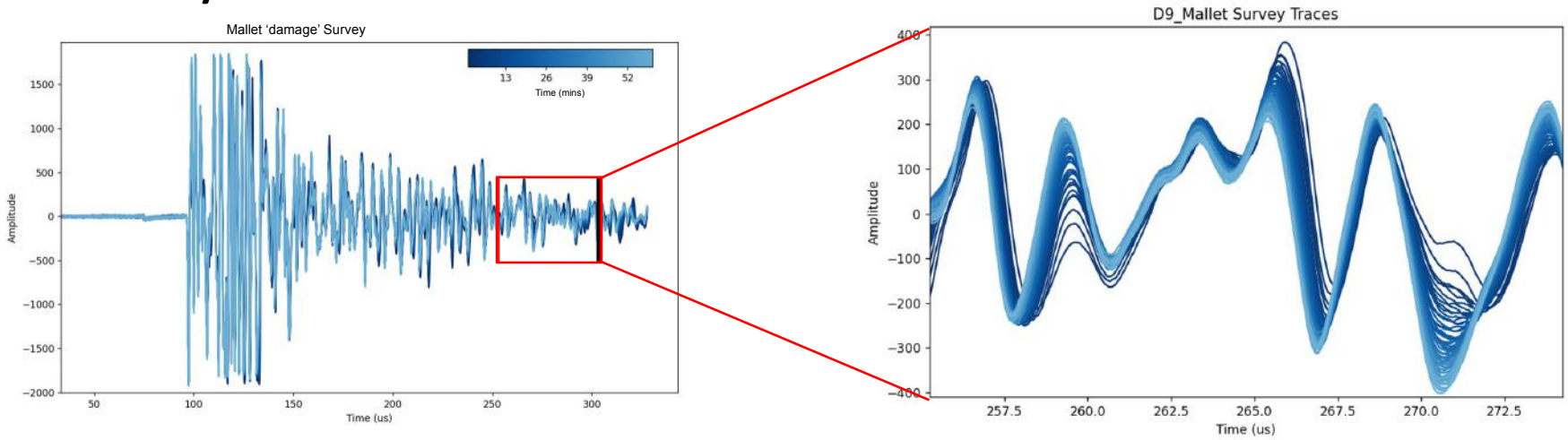
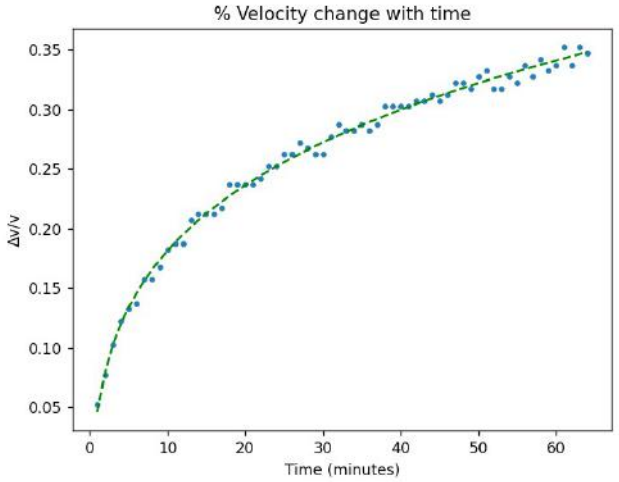
Laboratory observations of the ‘macro’





- Damage and healing cycles indicated by a decrease and subsequent recovery of velocities over time
- Small changes in the heterogeneities of rocks lead to small changes in elastic properties and velocities
- Coda-wave interferometry (CWI) allows us to see a path-averaging effect of these changes across the entire sample
- But what exactly is happening at the micro-scale?

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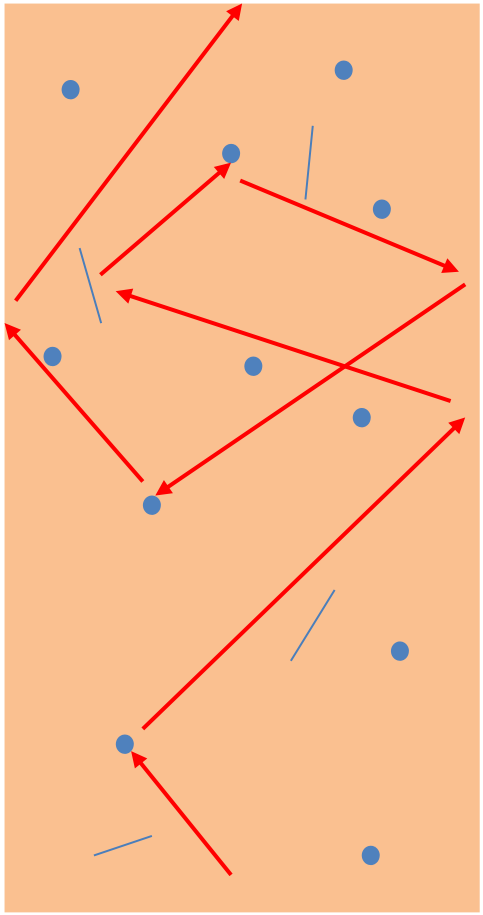

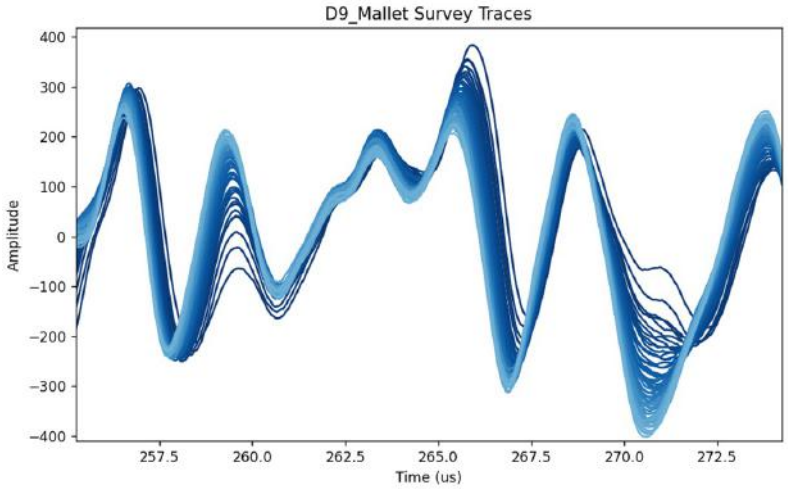

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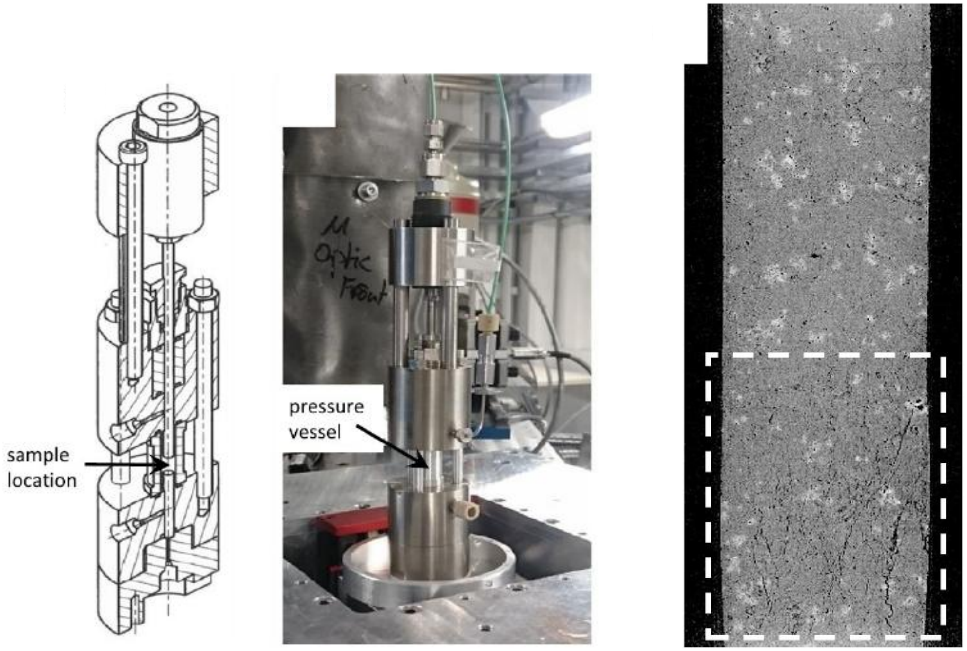
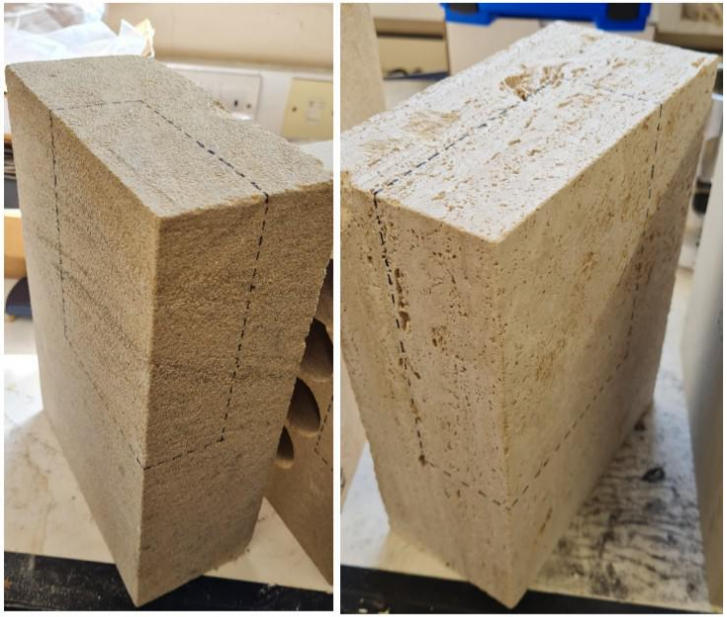
Imaging the 'micro' effect

- Stor Mjolnir: X-Ray transparent triaxial rock deformation apparatus
- Imaging grains/grain boundaries to provide new perspective on what physical processes occur at the micro-scale
- Effective pixel size of 2.5 µm, Grain size of 70-400 µm
- Local experiments will perhaps be sufficient to detect the locations of damage in the sample but may not image the damage itself
- Produce the case for why a synchrotron is necessary, and where we shall focus the imaging effort within the sample



(Cartwright-Taylor et. Al, 2020)

‘Soft’ Samples for imaging



Bentheimer

Tivoli_Travertine

Ketton LST

Thornton Dolomite

Locharbriggs

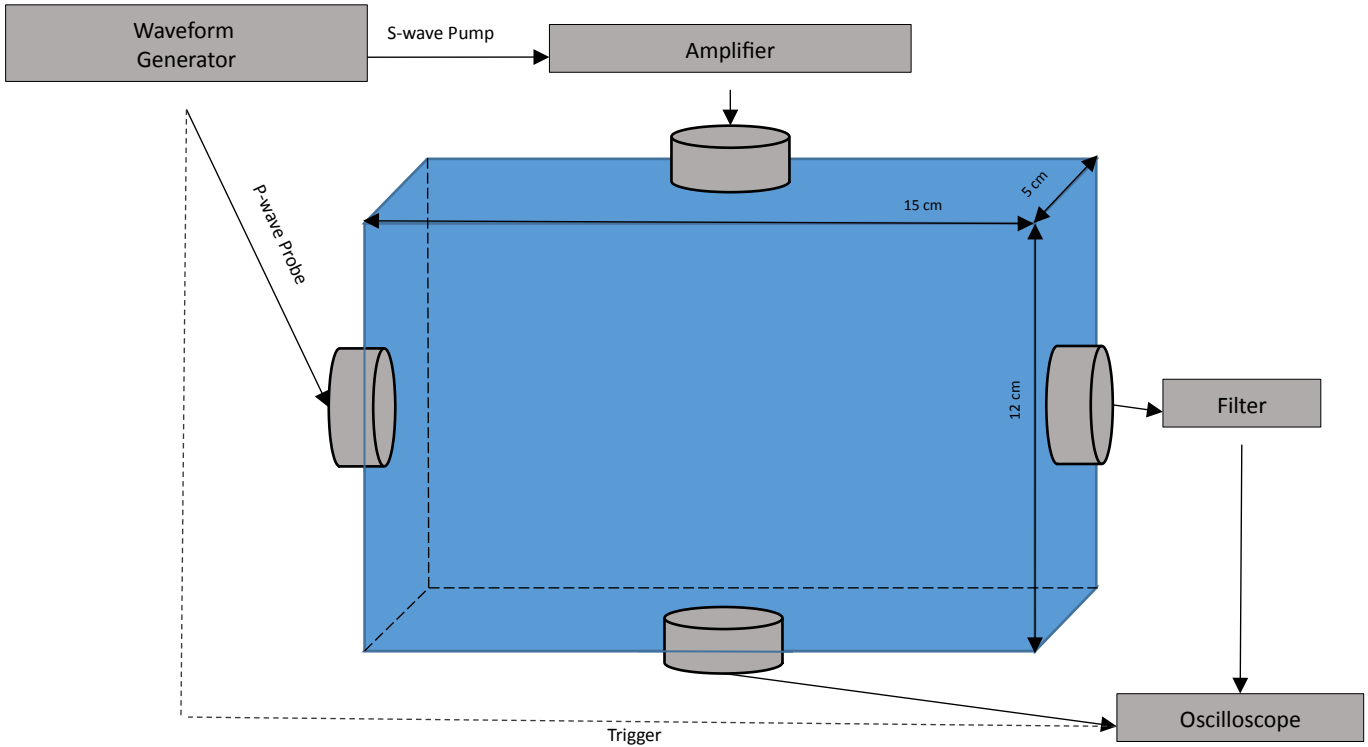
Gray Berea

D_Dale

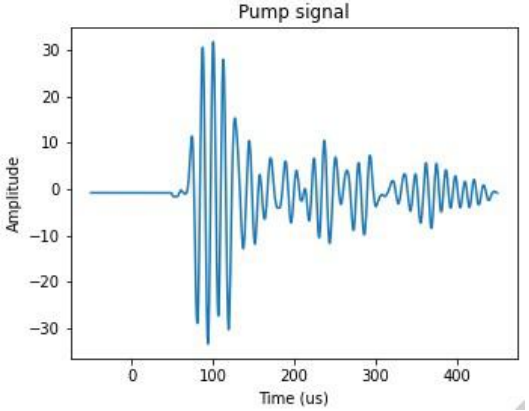
MEMORIAL UNIVERSITY

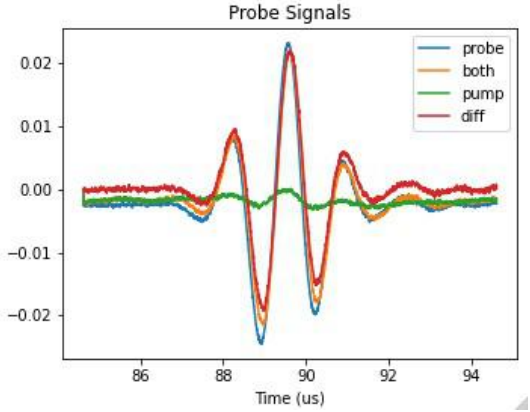
SPIN MONITORING A RESTLESS EARTH

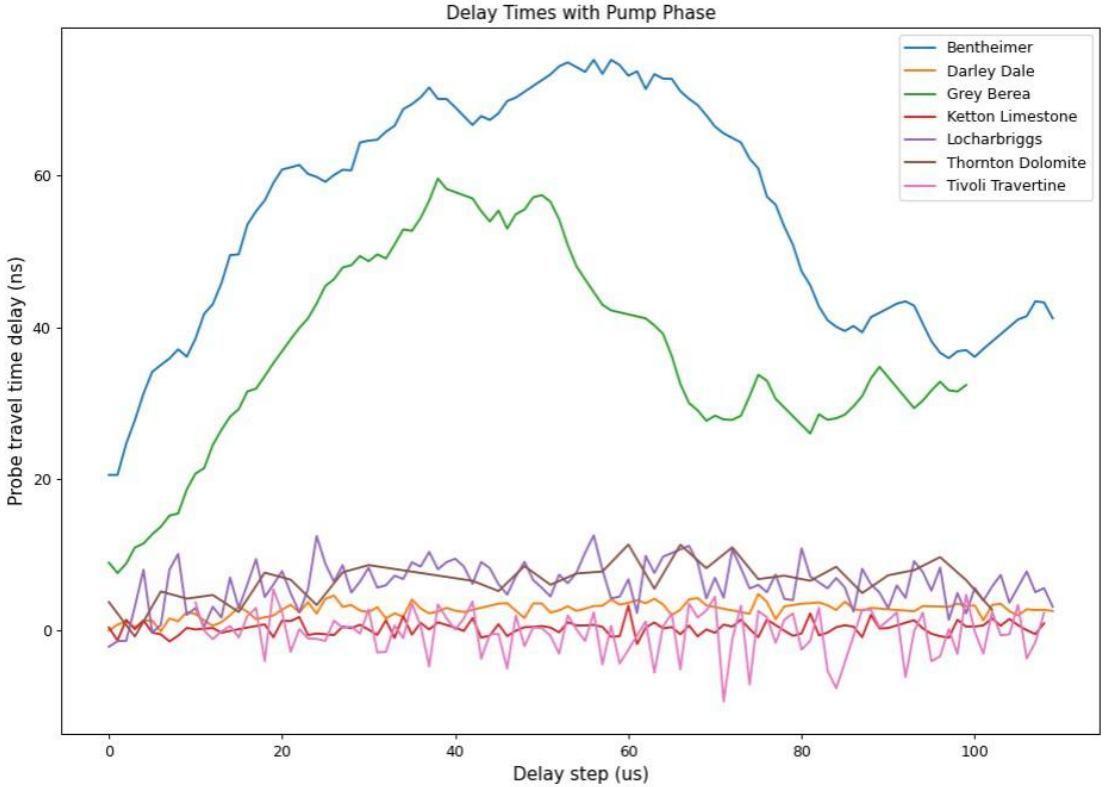
THE UNIVERSITY of EDINBURGH


Waveform Generator
S-wave Pump
Amplifier
P-wave Probe
15 cm
5 cm
12 cm
Filter
Oscilloscope
Trigger

Testing nonlinearity: a ‘pump and probe’ system







Future steps

- Building a case for use of synchrotron beam time using CT imaging in Edinburgh
- 'Permanent damage' theory by Ian Main:
  - Over numerous cycles of damage/healing, there may be a permanent weakening at high strains
  - Model that takes into account irreversible, permanent damage in a local volume, paired with a separate process of recoverable damage at much lower strains surrounding the damaged zone