The 3D evolution of localised and distributed strike slip shear zones; with insights into the development of the Marlborough Fault System, South Island, New Zealand



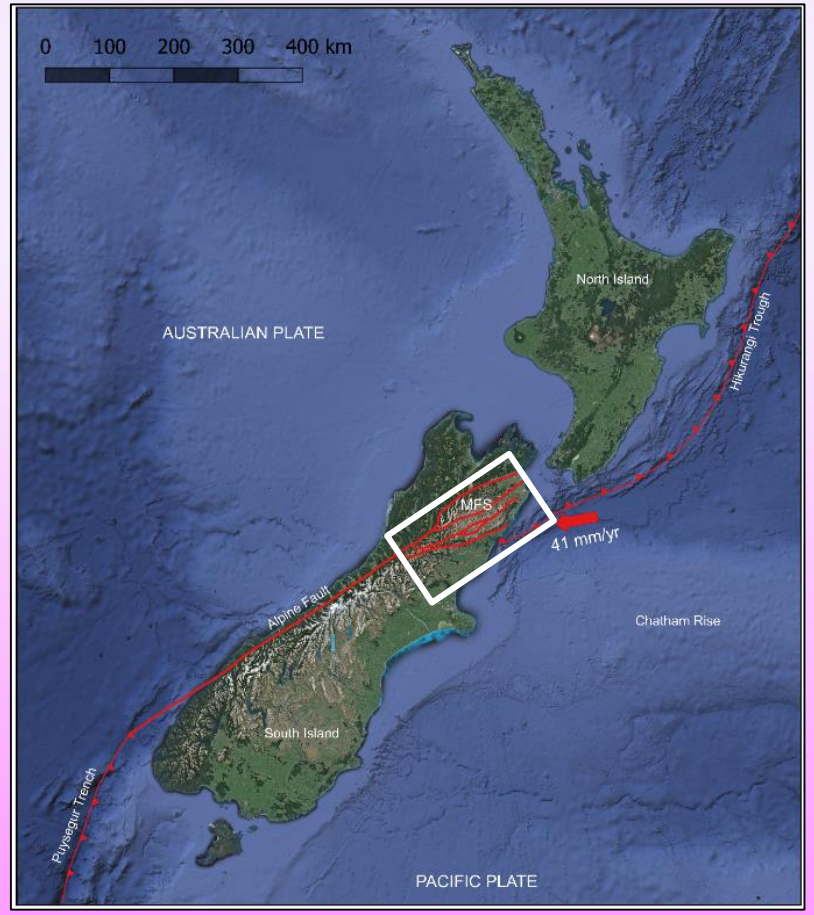
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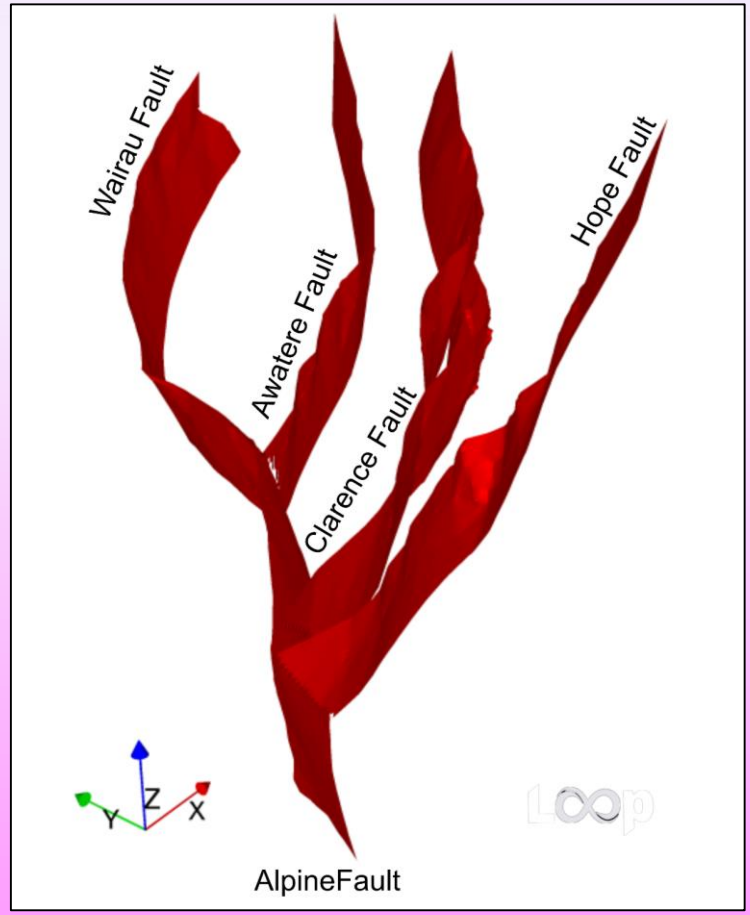
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- The Marlborough Fault System (MFS) is a series of oblique, dextral strike slip faults
- The MFS links subduction along the Hikurangi trough to continental collision on the Alpine Fault

Current hypothesis for MFS development

- Paleomagnetic data has been interpreted to show ~120° clockwise rigid block rotation
- After ~120 ° rigid block rotation, pre-existing weaknesses became favourably oriented for reactivation, forming the MFS



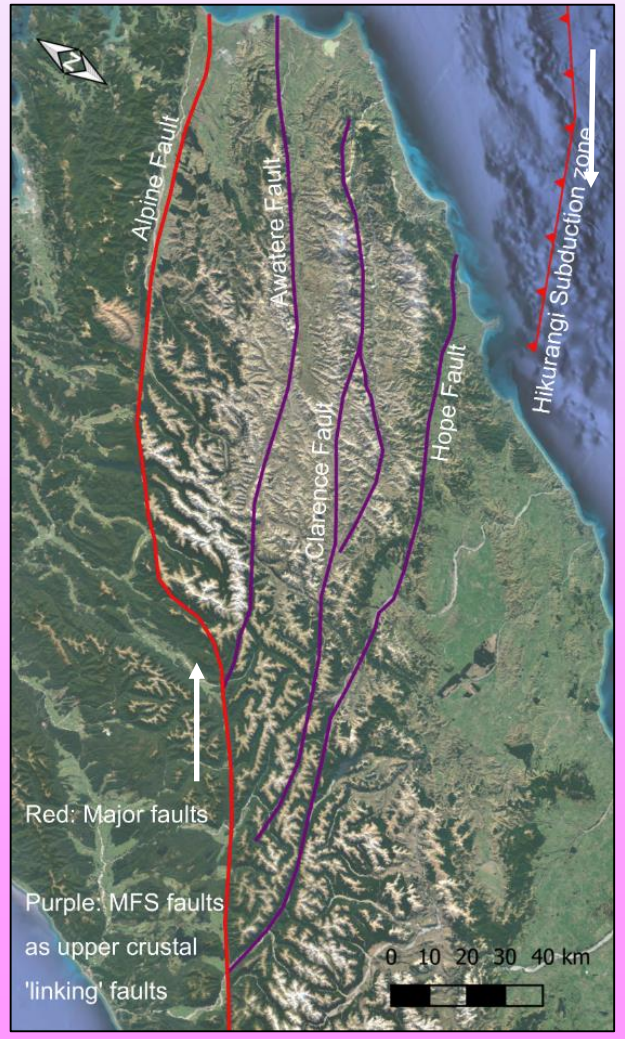


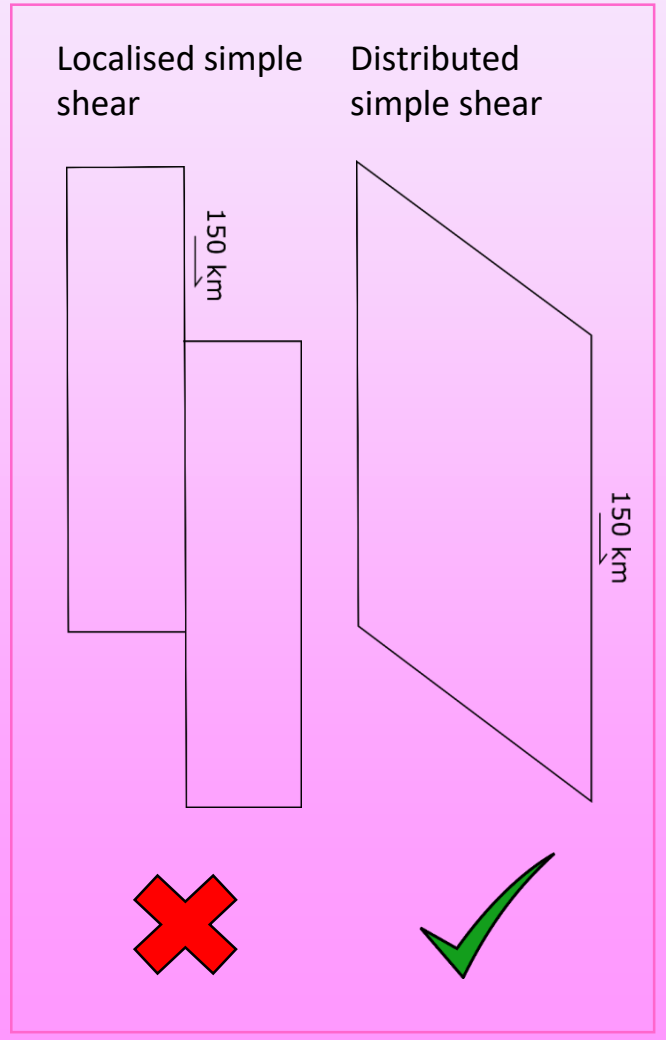
Localised vs Distributed simple shear

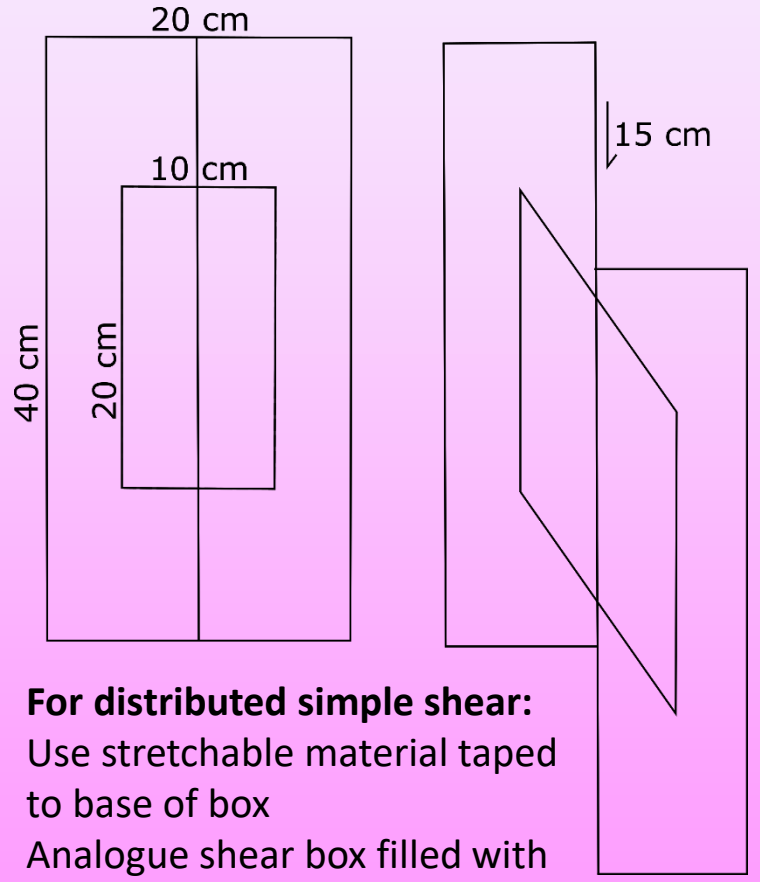
Problem:
The MFS deforms by distributed simple shear
Our analogue shear apparatus generates localised simple shear

Re-assess boundary conditions

Solution:
Design an analogue experiment that creates distributed simple shear







For distributed simple shear:
Use stretchable material taped to base of box
Analogue shear box filled with 2.5 cm sand
Compare result with localised simple shear model



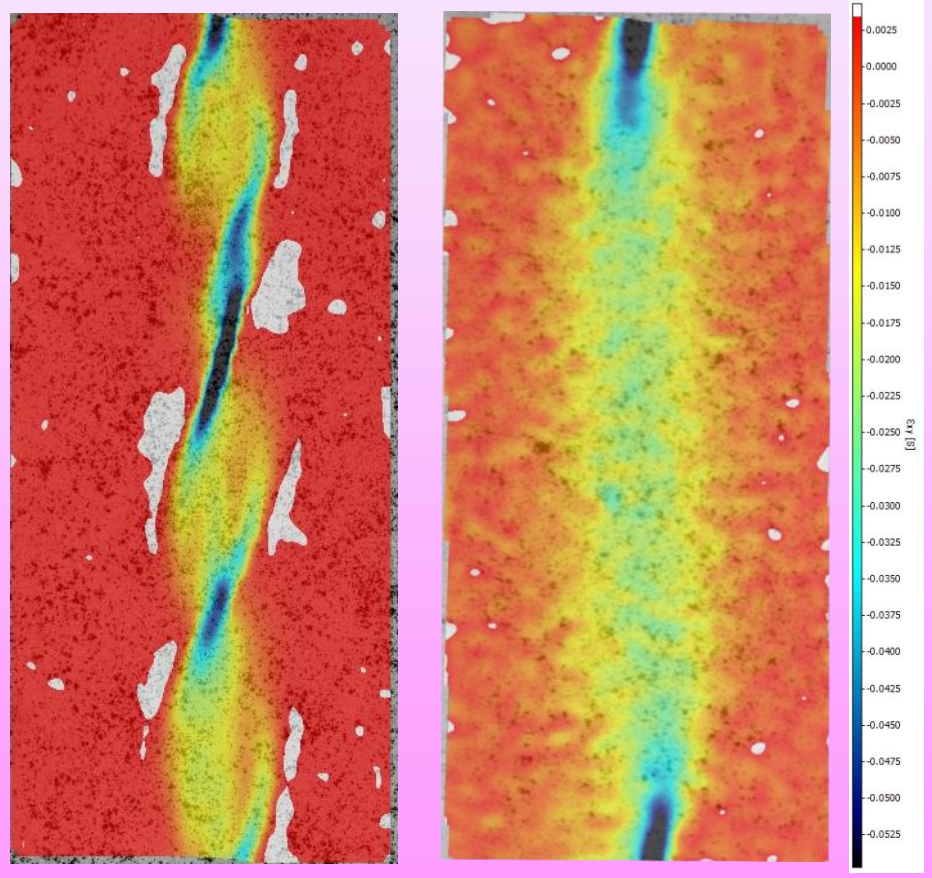
Box modification

Results:

Surface image of the analogue model, overlain by Exy differential shear strain map determined from Particle Imaging Velocimetry (PIV).
The colour represents the magnitude of differential shear strain.

Localised simple shear **Distributed simple shear**

Exy Differential shear strain map Displacement: 2.5 mm

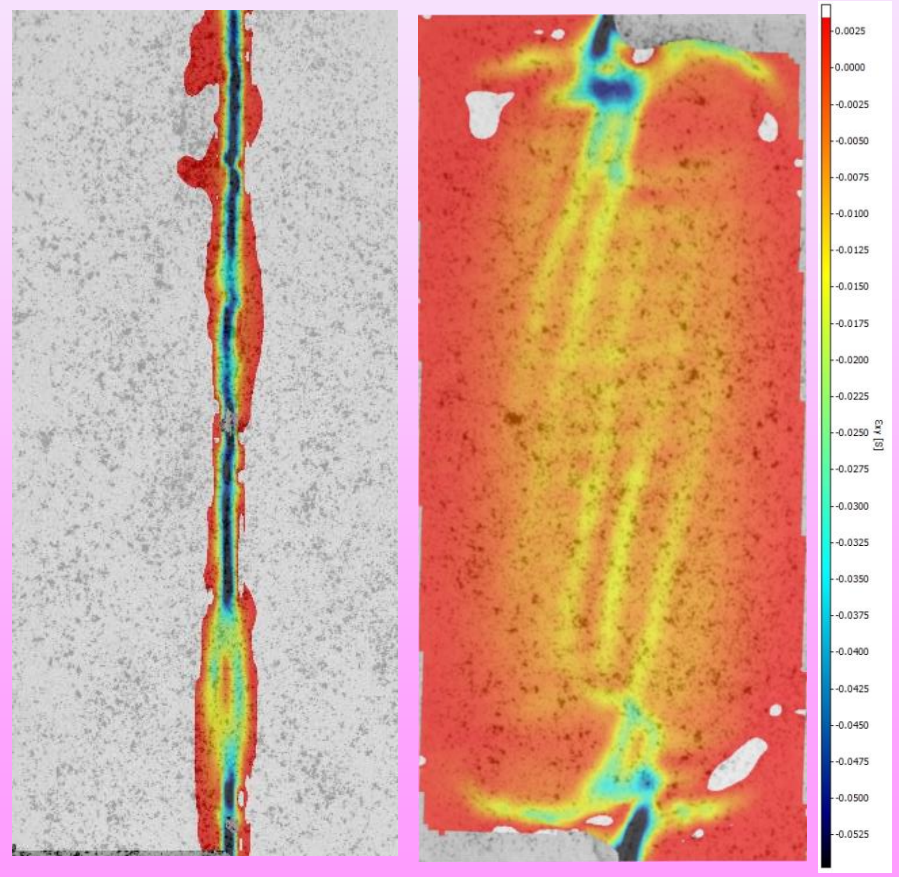


Riedal shears

No structures

Localised simple shear **Distributed simple shear**

Exy Displacement: 32.5 mm



Single localised fault oriented parallel to displacement direction

Multiple equally spaced faults oriented ~10° to displacement direction

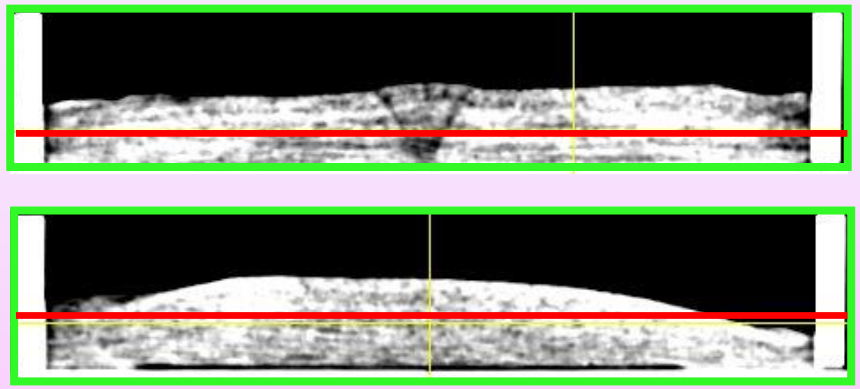
X-Rray CT Scanning

Inside the analogue model…

CT scans after 10 mm displacement

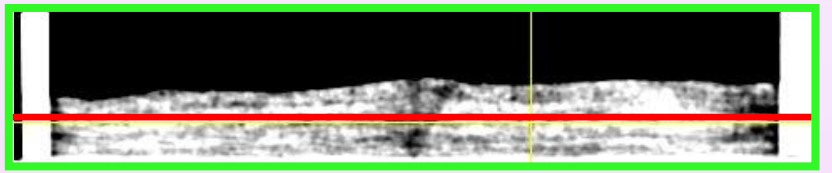
CT scans after 40 mm displacement

Vertical slices through centre of model

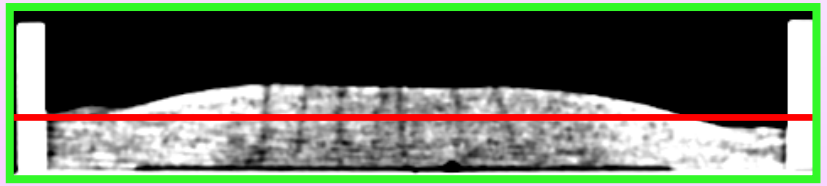


Localised simple shear

Distributed simple shear

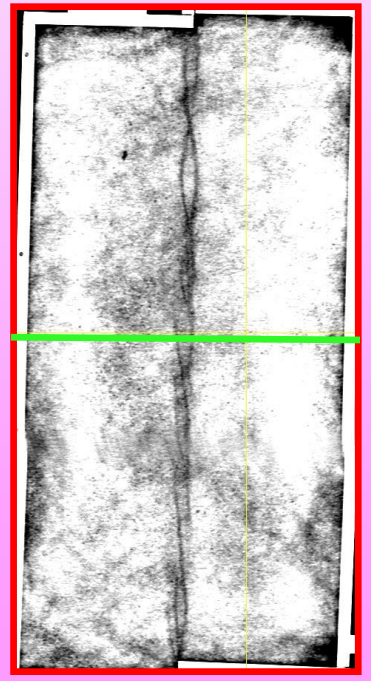


Localised simple shear

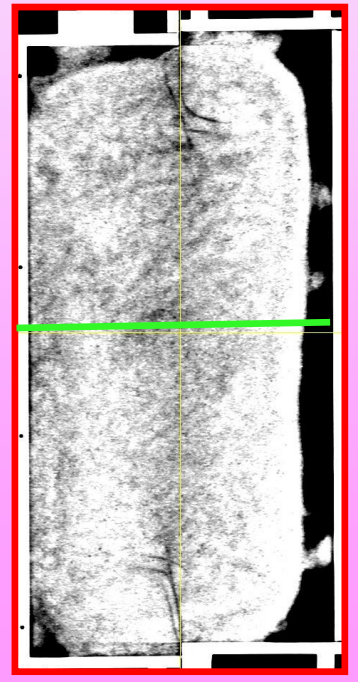


Distributed simple shear

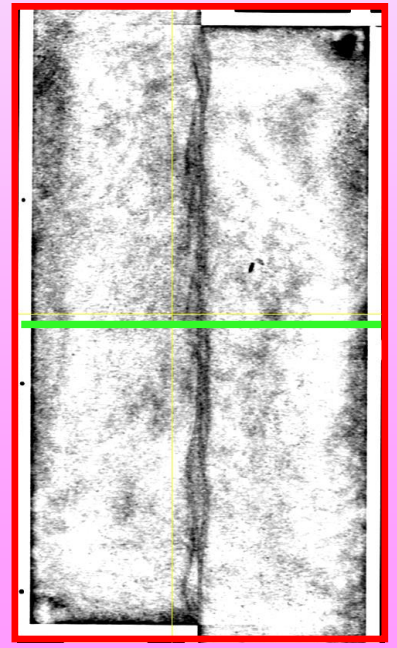
Horizontal slices through centre of model – location indicated above



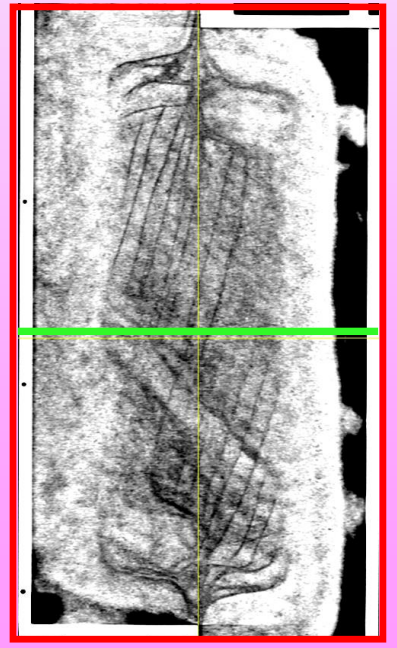
Localised simple shear



Distributed simple shear



Localised simple shear

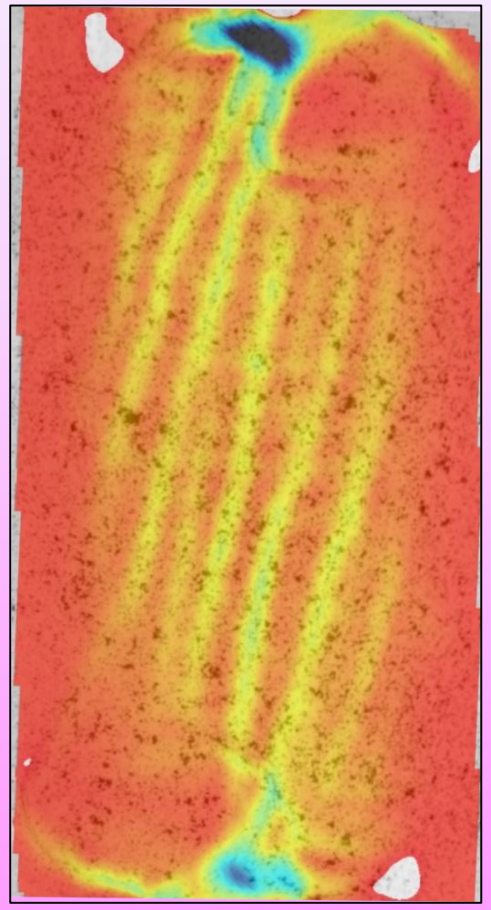


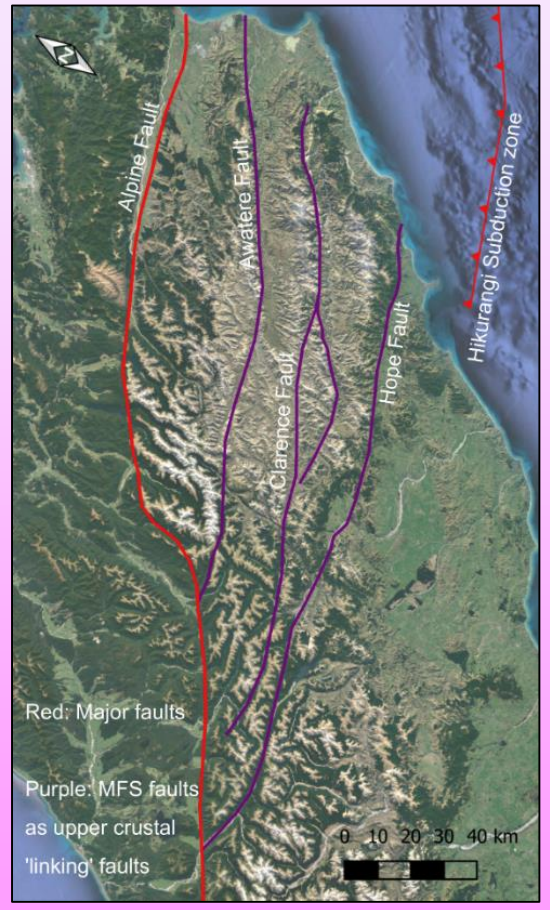
Distributed simple shear

Discussion

Comparison to Marlborough Fault System

Distributed simple shear





Similar orientations

Both images have faults with:

- Equal spacing
- Similar orientation relative to plate motion

Initial conclusions:

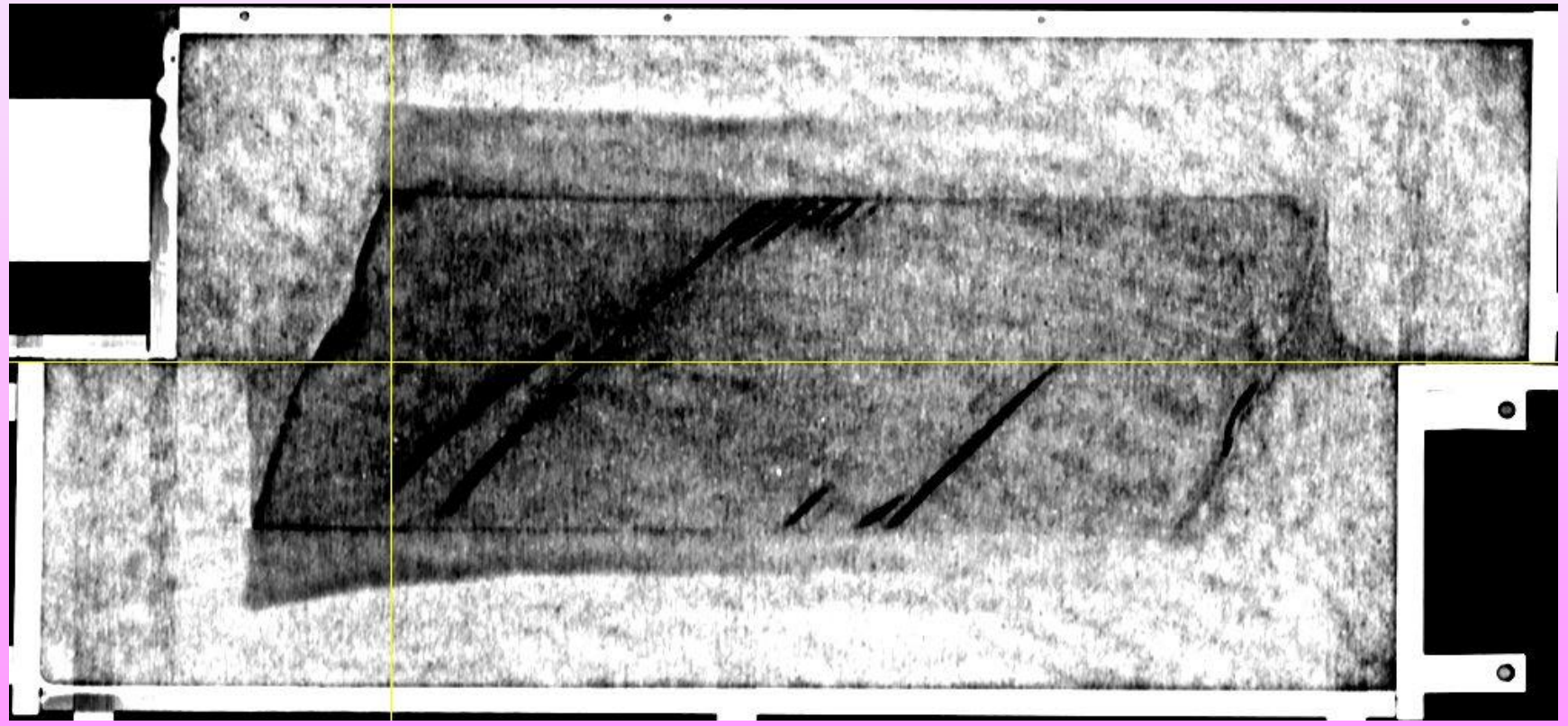
Formation of the Marlborough Fault System did not require rotation or the reactivation of pre-existing weaknesses to form

Rotation must be accommodated by localised shear zones and diffuse faulting

Bonus!

Here is CT scan showing the base of the distributed simple shear experiment at 40 mm displacement.

The stretchable material and tape can be seen in the CT scan image. At 40 mm displacement, folds develop in the stretchable material, and their hinge lines are oriented perpendicular to the bulk shortening direction, as observed in nature. These folds do not effect the outcome of the experiment at early stages of displacement.



Acknowledgements
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