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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• 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 $\sim 120^\circ$ clockwise rigid block rotation

• After $\sim 120^\circ$ 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

Solution:
Design an analogue experiment that creates distributed simple shear

Re-assess boundary conditions

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
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**
  - Exy Differential shear strain map
  - Displacement: 2.5 mm
- **Distributed simple shear**
  - Exy Displacement: 32.5 mm

### Riedal shears
- Single localised fault oriented parallel to displacement direction

### No structures
- Multiple equally spaced faults oriented ~10° to displacement direction
X-Ray CT Scanning

Inside the analogue model...

CT scans after 10 mm displacement

- Vertical slices through centre of model
  - Localised simple shear
  - Distributed simple shear

Horizontal slices through centre of model – location indicated above

- Localised simple shear
- Distributed simple shear

CT scans after 40 mm displacement

- Localised simple shear
- Distributed simple shear

Vertical slices through centre of model

- Localised simple shear
- Distributed simple shear

Horizontal slices through centre of model – location indicated above

- Localised simple shear
- Distributed simple shear
Discussion

Comparison to Marlborough Fault System

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.

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