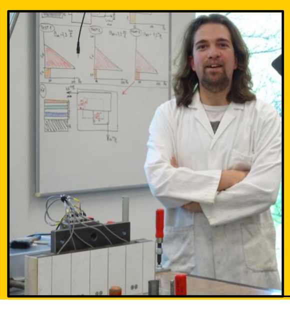
Force Sensor Measurements in Analogue Tectonic Models

A fault behavioural analysis in brittle compressional regimes



Joris Didden, Ernst Willingshofer, Jasper Smits, Bas van Dam, Job Arts

j.j.didden@students.uu.nl

Utrecht University

Faculty of Geosciences
Department of Earth Sciences
ESL -TecLab

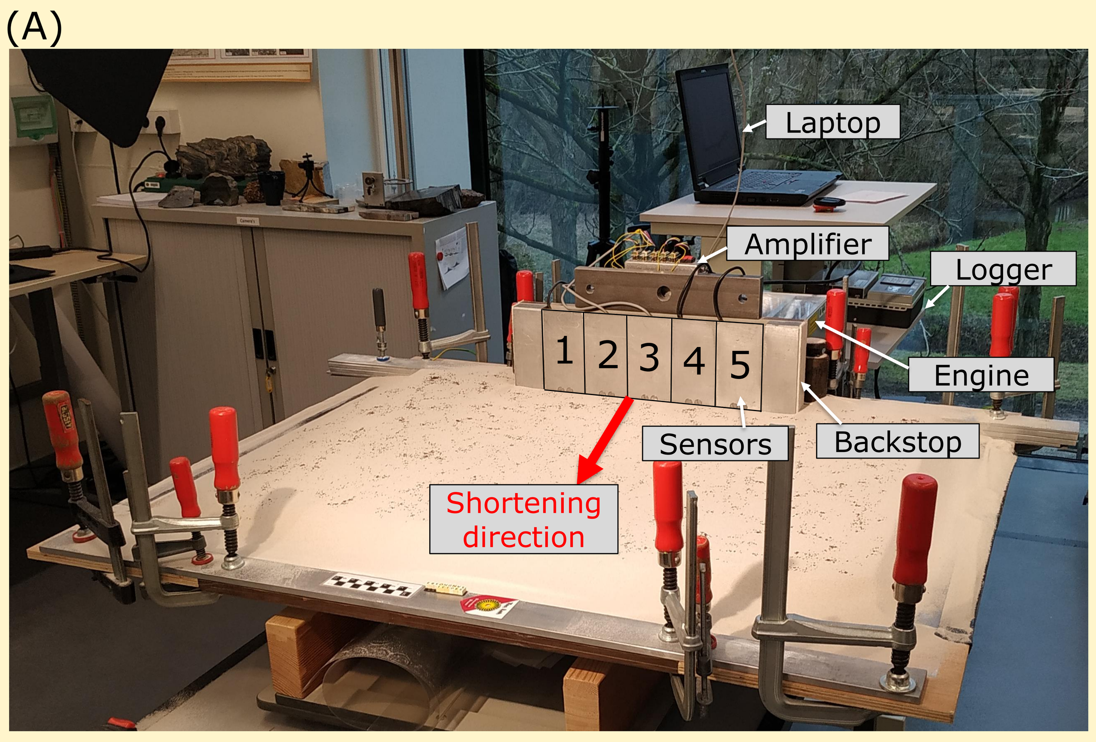
Objectives

We aim at developing methodology for measuring force changes related to fault formation at the highest possible resolution to facilitate the step towards a dynamic analysis of physical analogue models. Different to Ritter et al *(2018)*, we use an array of five force sensors, aligned along an indenting backstop which allows for characterizing force buildups and force drops associated with distributed and localized deformation.
Furthermore, this novel multiple force sensors approach provides critical data on lateral fault growth and allows for studying the force evolution of non-coaxial scenarios, i.e. experiments with lateral thickness or strength variations.

Methodology

Modelling Setup

(A)



Monitoring & Modelling Materials

(B)

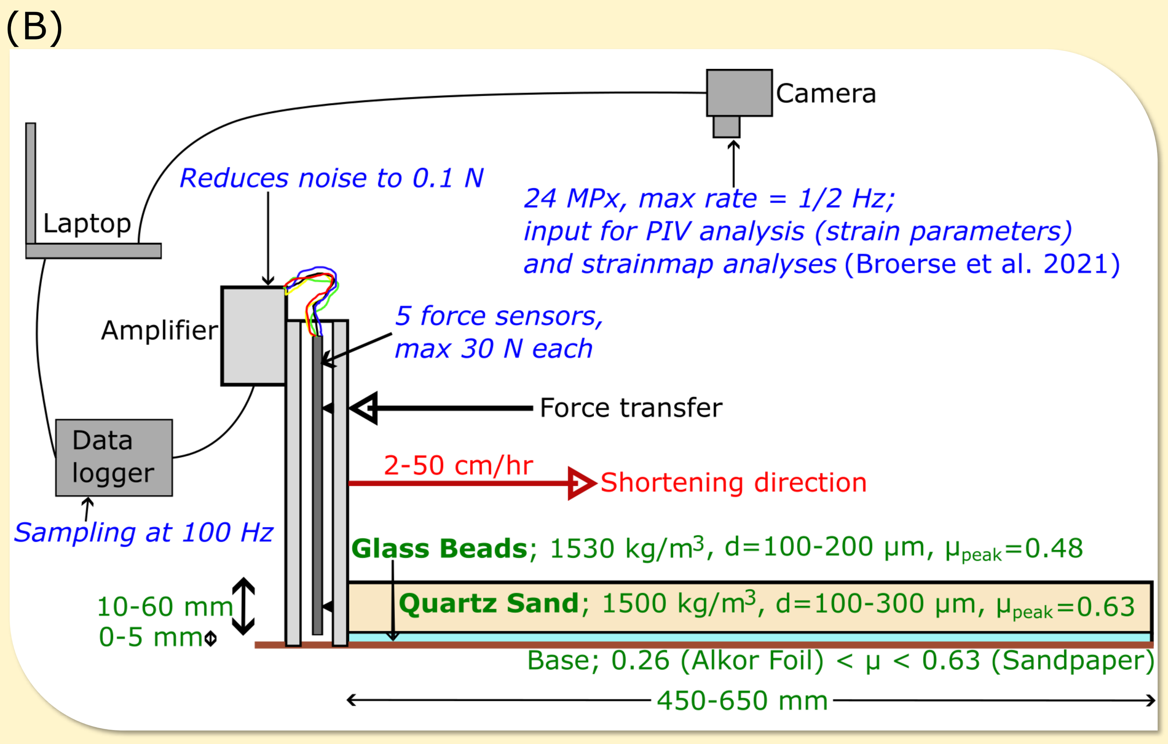


Figure 1; Photograph (a) and cross-sectional view (b) of the modelling setup. Monitoring parameters are given in blue; material properties and their ranges are given in green.

Long-term force evolution and fault formation

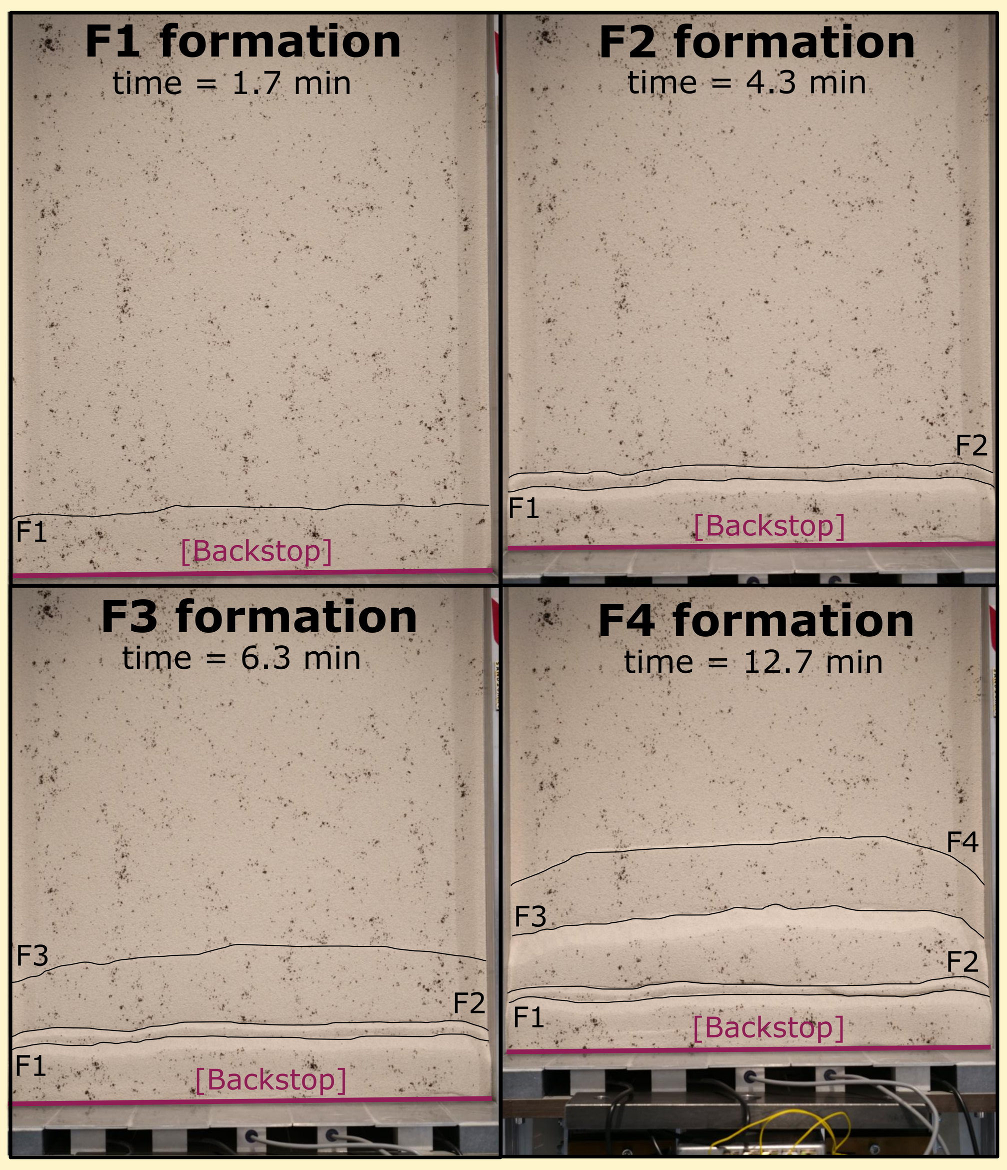


Figure 2; Structural evolution of the contractional analogue model in figure 3 portrayed by top-view images.

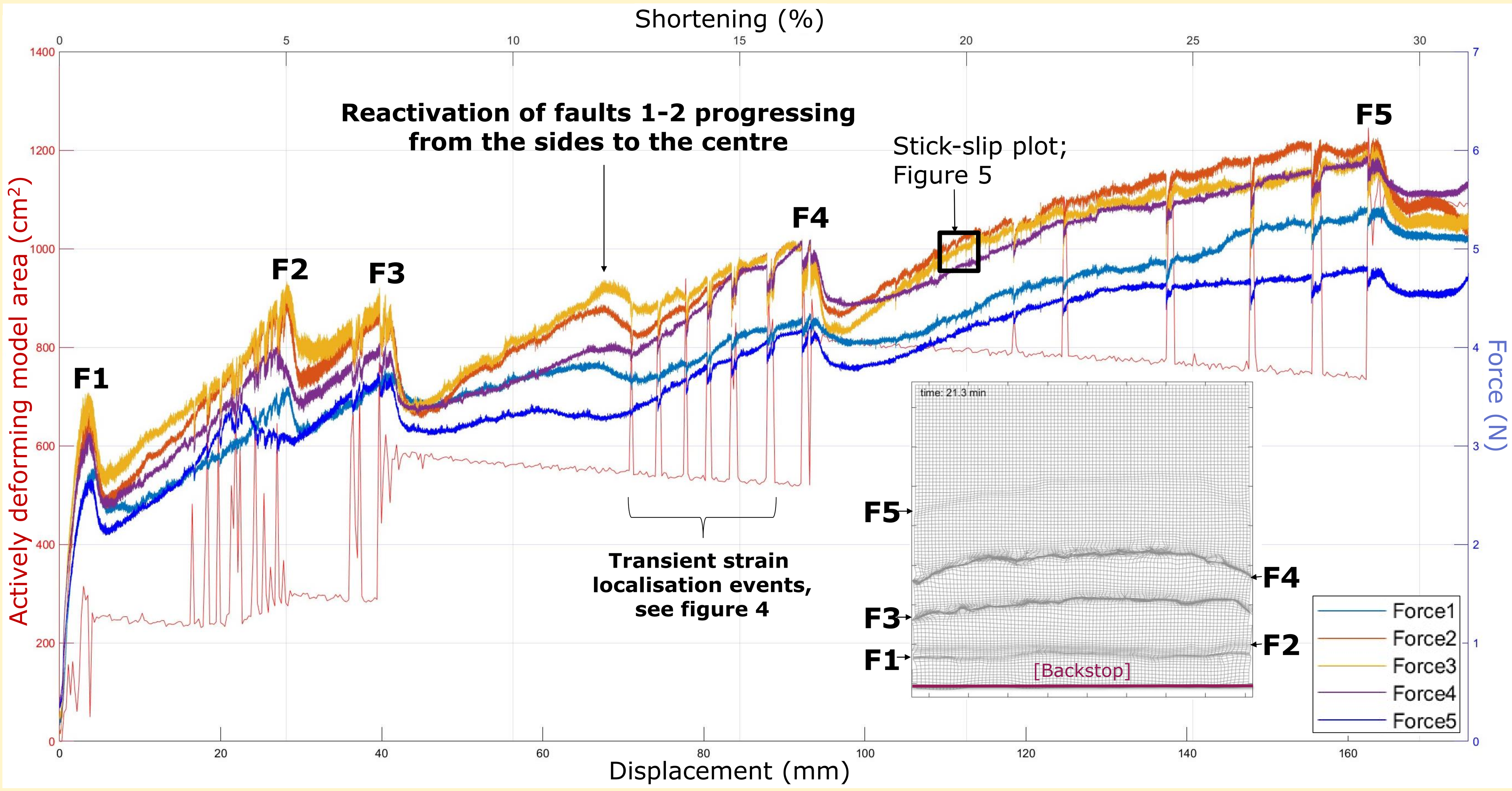


Figure 3; Long-term force evolution recorded by five force sensors. The force readings are synchronized to the evolution of the actively deforming area of the model. Inset: Final structure of the model where faults are represented by narrow zones of high cumulative strain for an experiment consisting of 5 mm glass beads overlain by 20 mm of quartz sand on top of Alkor Foil. Shortening velocity equals 48 cm/hr.

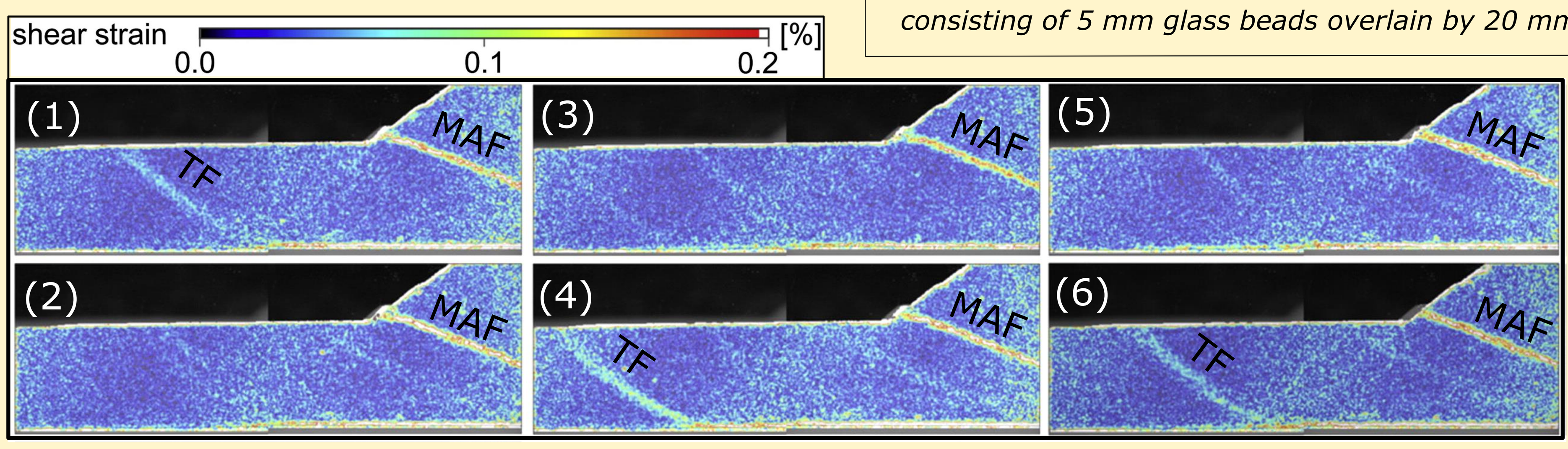


Figure 4; Cross sectional views of an analogue experiment showing incremental strain stages during shortening, modified from Dotare et al. (2016). Note transient fault (TF) localisation in front of the main active fault (MAF).

Preliminary Results

Fault formation and fault propagation are controlled by the frictional properties of the modelling materials.

- Glass beads at the base decreased the total number of faults but increased the lateral continuity of fault structures.
- Force magnitudes correlate with the thickness of the model and the frictional conditions at the base of the orogenic wedge such that high-friction models are thicker close to the backstop and have less faults, but show larger force build-ups and drops.

Short-term force evolution: stick-slips

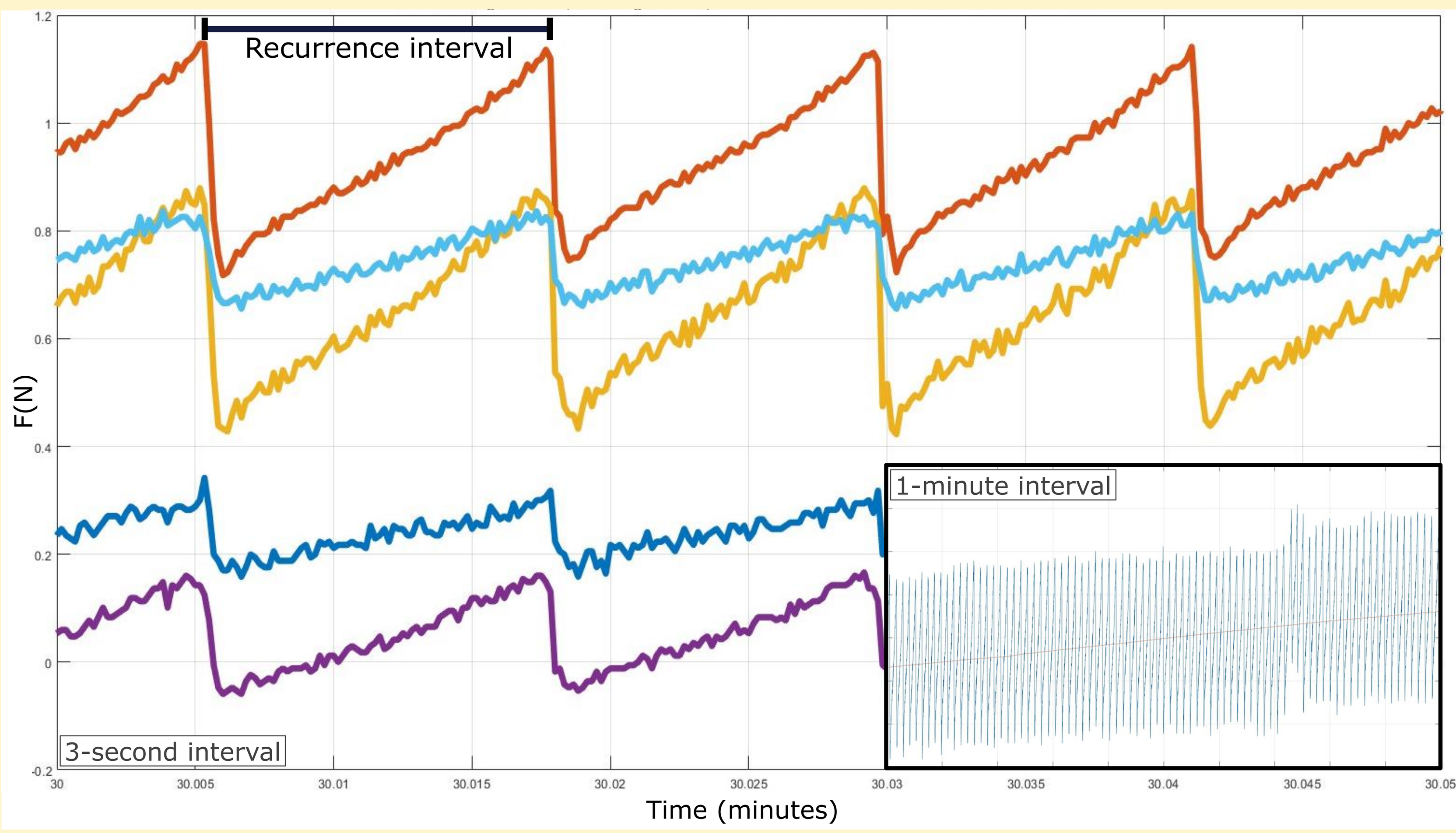


Figure 5; At high resolution, the force data suggest stick-slip behaviour during fault slip.

Preliminary Results

- Thick models, high basal frictions and high air moisture contents produced the most pronounced stick-slips.
- Elastic behaviour of the backstop also increased stick-slip amplitudes, by acting as a spring.
- Spectral analyses show the stick-slip recurrence interval becomes larger and more stable upon successive model thickening.

Future Studies

With our novel approach we can portray and quantify lateral force variations related to fault formation and fault propagation in analogue tectonic models. We aim to adapt this setup to the following scenarios:

- Quantifying force changes in response to initial lateral strength and thickness variations or pre-existing basement structures; example Jura Mountains.
- Quantifying force changes during the evolution of Riedel-type strike-slip systems.

References

- Broerse, T. et al. (2021). “Mapping and classifying large deformation from digital imagery: application to analogue models of lithosphere deformation”. In: Geophysical Journal International 226.2, pp. 984–1017.
- Dotare, T. et al. (2016). “Initiation of a thrust fault revealed by analog experiments”. In: Tectonophysics 684, pp. 148–156.
- Ritter, M. C. et al. (2018). “Sandbox rheometry: Co-evolution of stress and strain in Riedel- and Critical Wedge-experiments”. In: Tectonophysics 722, pp. 400–409.