Digital Image Correlation reveal fault evolution within releasing bend experiments with different strength wet kaolin (https://doi.org/10.5880/fidgeo.2024.015)

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1. Licence

2. Citation

When using the data please cite:

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The data are supplementary material to:
Gabriel, A.; Elston, H.; Cooke, M.; Ramos Sanchez, C. (2025), Impact of material strength on releasing bend evolution. Tektonika, https://doi.org/10.55575/tektonika2025.3.1.81

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3. Data Description

The data set includes the Digital Image Correlation (DIC) results for four experiments of releasing bends along dextral strike-slip faults that were performed at the University of Massachusetts at Amherst (USA). Gabriel et al. (2025) used the DIC data sets to investigate how releasing bend fault systems evolve within different strength wet kaolin. Information on the experimental set up and methods can be found in the main text and supplement to Gabriel et al. (2025). The data here include the incremental displacement time series, strain animation and surface elevation data at the end of the two experiments with different clay strength, which are presented within Gabriel et al. (in prep). We also include in this data repository incremental displacement time series and strain animations from two experiments that repeat the conditions of the experiments featured in Gabriel et al. (2025).

3.1. Experiment setup and processing methods

We document the evolution of two restraining bends along dextral strike-slip faults within 2.5 cm thick wet kaolin. Computer-controlled stepper motors displace one side of a split box apparatus that has a basal plate discontinuity with a 30° releasing bend that has a 5 cm step over. Prior to initial loading, we cut a vertical fault surface following the basal plate discontinuity. All four experiments have the same boundary conditions and loading rate of 0.5 mm/min. We vary the water content of the wet kaolin used in the experiments so that the clay has undrained shear strength of either ~80 or ~110 Pa (Gabriel et al. in prep). We ran two experiments of each strength in order to assess repeatability of releasing bend fault evolution.

Overhead cameras capture the distribution of red and black sand grains on the surface of the clay every ~0.25 mm of applied displacement. The sand grains provide pixel constellations that DIC track between successive images to calculate the incremental horizontal displacement field. All images are corrected for camera lens distortion prior to DIC. Because dip slip along normal faults exposes fresh clay surfaces, we add sand to the surface as needed during the experiments to allow displacement calculations along the fault scarps. We use the DIC technique of Particle Image Velocimetry (PIV) to calculate the incremental horizontal displacement field between successive experiment images. The addition of sand disrupts the PIV analysis of for photos before and after addition of sand and we remove those these frames from the analysis.

We use the Matlab™ based PIVlab (Thielicke and Stamhuis, 2014) with a fast Fourier transform three-pass filter to optimize displacement resolution. With an image resolution of 153-164 pixels per cm, a final step size of 8 pixels produces an incremental displacement data point every~ 0.5 mm. To create strain maps we first apply a 5-point median filter to the incremental displacement fields and then stack the relatively noisy divergence of the incremental horizontal displacement maps over five stages. The ratio of the vorticity (2 times the curl) and divergence informs the sense of strain.

To measure the surface topography at the end of the experiment we use the Structure from Motion approach of Metashape™. Metashape™ merges images from five cameras along with x,y and z positions of 12 control points to create a three-dimensional point cloud of the experiment surface. We crop the point cloud to the releasing bend region which results in a data cloud of c. 1 million points.

4. File description

This data set includes time series of incremental horizontal displacement maps and strain animations for 4 experiments performed at the University of Massachusetts Amherst in April and August of 2022 as well as June of 2023. We also include surface elevation data for the end of the April and August 2022 experiments. The netCDF files include time series data for each experiment. Each netCDF file contains the following:

- *ux* = the incremental displacement field within the Region Of Interest (ROI) parallel to the margin (x-direction). The third dimension in the array corresponds to increment of deformation through the experiment. Units are mm.
- *uy* = the incremental displacement field within the ROI perpendicular to the margin (y-direction). The third dimension in the array corresponds to increment of deformation through the experiment. Units are mm.
- *x* = position parallel to the primary strike-slip fault. Units are mm.
- *y* = position perpendicular to the primary strike-slip fault. Units are mm.

The MP4 animations files show strain evolution of the experiments (see table 2 for description). The strain evolution animations overlay colormaps of incremental strain between successive photos on photographs of the experiment surface that are corrected for camera lens distortion. Color saturation indicates the incremental net strain rate and hue indicates the sense of strain.

The txt files contain the positions of the data cloud points produced by the structure from motion analysis for the end of the experiments. Each line of the file contains the double precision x, y and z positions of a surface data point separated by spaces. The z position reports elevation of the scattered points and all units are mm.

4.1. File inventory and naming convention

The following table lists the names of the files included within the repository. All filenames have the following general structure "2024-015_Gabriel-et-al_[No]_[File name in Table 1]". The latter reflect the date of the experiment using the US standard of month followed by day and then the last two digits of year.

Table 1: File inventory

No	File name	Type	Description
01	04_08_22_stronger_disp.nc	netCDF	Incremental displacement time series
02	04_08_22_stronger_surface.txt	txt	Elevation at the end of the experiment
03	04_08_22_stronger_ strain.mp4	MP4	Incremental net strain animation
04	08_31_22b_stonger_disp.nc	netCDF	Incremental displacement time series
05	08_31_22b_stronger_surface.txt	txt	Elevation at the end of the experiment
06	08_31_22b_stronger_ strain.mp4	MP4	Incremental net strain animation
07	06_24_23a_stronger_disp.nc	netCDF	Incremental displacement time series
08	06_24_23a_stronger_strain.mp4	MP4	Incremental net strain animation
09	06_24_23b_weaker_disp.nc	netCDF	Incremental displacement time series
10	06_24_23b_weaker_strain.mp4	MP4	Incremental net strain animation

5. References

Thielicke, W., & Stamhuis, E. J. (2014). PIVlab – Towards User-friendly, Affordable and Accurate Digital Particle Image Velocimetry in MATLAB. In Journal of Open Research Software (Vol. 2). https://doi.org/10.5334/jors.bl

Gabriel, A.; Elston, H.; Cooke, M.; Ramos Sanchez, C. (2025), Impact of material strength on releasing bend evolution. Tektonika, https://doi.org/10.55575/tektonika2025.3.1.81