A database of analogue models and geophysical data investigating caldera resurgence; DynamiCal project, ILGE-MEET TNA/NOA

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1. Licence

2. Citation

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3. Additional information

The analogue modelling experiments were carried out at the TOOLab (Tectonic Modelling Laboratory), which is a joint laboratory between the *Istituto di Geoscienze e Georisorse* of the *Consiglio Nazionale delle Ricerche, Italy* and the *Department of Earth Sciences* of the *University of Florence*. The laboratory work that produced these data was partly supported by the European Plate Observing System (EPOS), by the Joint Research Unit (JRU) EPOS Italia and by the "Monitoring Earth's Evolution and Tectonics" (MEET) project (NextGenerationEU, project IDIR0000025). Specifically, this work was performed in the frame of the DynamiCal project, funded by the 2° TNA-NOA call of the ILGE-MEET project.

4. Dataset description

In this dataset we provide data for 6 experimental models of caldera collapse and subsequent resurgence monitored through geophysical sensors (a force or "impact sensor", Piezotronics PCB 104 200B02 and a Triaxial piezoelectric accelerometer, Model 356B18). The setup and materials for the caldera collapse analogue models are the same described in Bonini et al. (2021) and Maestrelli et al. (2021a, b). Specifically, we used a Quartz and K-feldspar sand mixture (70:30 % proportion in weight; Montanari et al., 2017a, Del Ventisette et al., 2019) to simulate the overburden, and Polyglycerine-3 (kindly provided by Spiga Nord S.p.A) as analogue material for magma (Montanari et al., 2017b). Table 1 summarizes the main analogue modelling parameters and the geophysical sensors adopted to monitor the dynamic parameters during model deformation. All the caldera collapse models were run with a similar setup, while during the subsequent caldera resurgence phase we varied the reinjection depth, in order to obtain different structural and topographic pattern, similarly to what has been done in Bonini et al. (2021). Figure 1 shows a sketch of the modelling setup. Specifically, the provided dataset contains high quality photos of model deformation, surface topography and the geophysical data acquired during the experiments. Details are provided in Chapter 6.

Analogue Model Name	Magma chamber thickness (cm)	Magma chamber diameter (cm)	Depth of the magma chamber top (cm)	Geophysical sensors	Depth of the impact sensor below magma chamber top (cm)	Type of caldera resurgence
CSS-4	2	12	6	Piezotronics PCB 104 200B02 (Impact sensor) + Triaxial piezoelectric accelerometer (Model 356B18)	1	Piston like resurgence
CSS-5	2	12	6	Piezotronics PCB 104 200B02 (Impact sensor) + Triaxial piezoelectric accelerometer (Model 356B18)	1	Piston like resurgence + Deep dyke intrusion
CSS-6	2	12	6	Piezotronics PCB 104 200B02 (Impact sensor) + Triaxial piezoelectric accelerometer (Model 356B18)	1	Piston like resurgence
CSS-7	2	12	6	Piezotronics PCB 104 200B02 (Impact sensor) + Triaxial piezoelectric accelerometer (Model 356B18)	1	Saucer-shape + shallow dyke intrusion
CSS-8	2	12	6	Piezotronics PCB 104 200B02 (Impact sensor) + Triaxial piezoelectric accelerometer (Model 356B18)	1	Piston like resurgence
CSS-9	2	12	6	Piezotronics PCB 104 200B02 (Impact sensor) + Triaxial piezoelectric accelerometer (Model 356B18)	1	Shallow dyke intrusion

Table 1. *Overview of modelling setup parameters. For more details on modelling setup and analogue materials refer to Bonini et al., 2021 and Maestrelli et al.(2021a,b).*

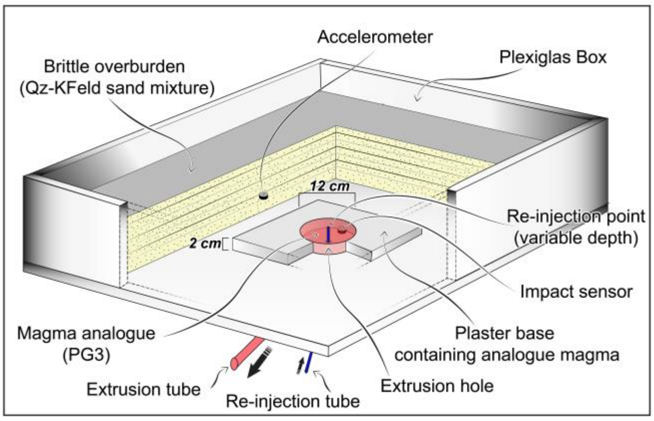

__Figure 1.__ Modelling setup for analogue experiments. The location of the geophysical sensors is indicated in the sketch. The reinjection depth was varied depending on the model (modified from Maestrelli et al., 2021a,b).

5. File description

In this dataset we provide the following type of data:

Analogue models:

- Movies (.mp4 format) obtained from high-resolution top-view photos acquired during analogue model deformation.
- Photos (.jpg format) of incremental analogue model deformation.
- 3D rendering of analogue models (.pdf format)
- Digital Elevation Models (DEMs, provided as .tif format files) of triple junction analogue models.

Geophysical data:

- Acceleration data (.csv format) obtained with a triaxial accelerometer
- Pressure data (.csv format) obtained with an impact sensor
- A Matlab® script (.mat and .txt format) that can be used to read and plot the data mentioned above

5.1 File inventory

Analogue models					
Folder	**Sub-folder**	**Sub-dataset description**	**File format**	**File/subfolder name**	**File description**
2025-071_ Sanchez-et-al_ **analogue-models**	2025-071_ Sanchez-et-al_ **3D-rendering-of-analogue-models**	This sub-folder contains the 3D rendering of the analogue models at the end of deformation	.pdf	CSS-4_3D	3D rendering for Model CSS-4
				CSS-5_3D	3D rendering for Model CSS-5
				CSS-6_3D	3D rendering for Model CSS-6
				CSS-7_3D	3D rendering for Model CSS-7
				CSS-8_3D	3D rendering for Model CSS-8
				CSS-9_3D	3D rendering for Model CSS-9
	2025-071_ Sanchez-et-al_ **Cross-sections-of-analogue-models**	This sub-folder contains the photos of cross sections for analogue model	.jpg	CSS-4_CROSS-SECTION	Cross section for Model CSS-4 after caldera resurgence
				CSS-5_CROSS-SECTION	Cross section for Model CSS-5 after caldera resurgence
				CSS-6_CROSS-SECTION	Cross section for Model CSS-6 after caldera resurgence
				CSS-7_CROSS-SECTION	Cross section for Model CSS-7 after caldera resurgence
				CSS-8_CROSS-SECTION	Cross section for Model CSS-8 after caldera resurgence
				CSS-9_CROSS-SECTION	Cross section for Model CSS-9 after caldera resurgence

	2025-071_ Sanchez-et-al_ **DEMs-of-analogue-models**	This sub-folder contains the geotif Digital Elevation Model (DEM) files obtained for analogue models	.tif	CSS-4_DEM	DEM for Model CSS-4 after caldera resurgence
				CSS-5_DEM	DEM for Model CSS-5 after caldera resurgence
				CSS-6_DEM	DEM for Model CSS-6 after caldera resurgence
				CSS-7_DEM	DEM for Model CSS-7 after caldera resurgence
				CSS-8_DEM	DEM for Model CSS-8 after caldera resurgence
				CSS-9_DEM	DEM for Model CSS-9 after caldera resurgence
	2025-071_ Sanchez-et-al_ **Movies-of-analogue-models-deformation**	This sub-folder contains the movies showing the top-view evolution of deformation for each model	.mp4	CSS-4_MOVIE	Shows deformation for Model CSS-4
				CSS-5_MOVIE	Shows deformation for Model CSS-5
				CSS-6_MOVIE	Shows deformation for Model CSS-6
				CSS-7_MOVIE	Shows deformation for Model CSS-7
				CSS-8_MOVIE	Shows deformation for Model CSS-8
				CSS-9_MOVIE	Shows deformation for Model CSS-9
	2025-071_ Sanchez-et-al_ **Photos-of-analogue-models-deformation**	This sub-folder contains folders with all photos acquired during analogue model deformation	.jpg	2025-071_ Sanchez-et-al_ CSS-4_PHOTOS	Photos of deformation for Model CSS-4
				2025-071_ Sanchez-et-al_ CSS-5_PHOTOS	Photos of deformation for Model CSS-5
				2025-071_ Sanchez-et-al_ CSS-6_PHOTOS	Photos of deformation for Model CSS-6
				2025-071_ Sanchez-et-al_ CSS-7_PHOTOS	Photos of deformation for Model CSS-7
				2025-071_ Sanchez-et-al_ CSS-8_PHOTOS	Photos of deformation for Model CSS-8
				2025-071_ Sanchez-et-al_ CSS-9_PHOTOS	Photos of deformation for Model CSS-9

Table 2. *File inventory of 2025-071_Sanchez-et-al_analogue-models.*

Geophysical data					
Folder	**Sub-folder**	**Sub-dataset description**	**File format**	**File/subfolder name**	**File description**
2025-071_ Sanchez-et-al_ **geophysical-data**	2025-071_ Sanchez-et-al_ **Pres_Acc_Data**	This sub-folder contains the .zip folders which contain the accelerometer and pressure data for the models both for Collapse and Resurgence	.csv	CSS-4_CO	Time (in s), acceleration (X, Z in V) and pressure (IMPACT SENSOR in V) data for the collapse phase of Model CSS-4
				CSS-5_CO	Time (in s), acceleration (X, Z in V) and pressure (IMPACT SENSOR in V) data for the collapse phase of Model CSS-5
				CSS-6_CO	Time (in s), acceleration (X, Z in V) and pressure (IMPACT SENSOR in V) data for the collapse phase of Model CSS-6
				CSS-7_CO	Time (in s), acceleration (X, Z in V) and pressure (IMPACT SENSOR in V)) data for the collapse phase of Model CSS-7
				CSS-8_CO	Time (in s), acceleration (X, Z in V) and pressure (IMPACT SENSOR in V) data for the collapse phase of Model CSS-8
				CSS-9_CO	Time (in s), acceleration (X, Z in V) and pressure (IMPACT SENSOR in V) data for the collapse phase of Model CSS-9
				CSS-4_RE	Time (in s), acceleration (X, Z in V) and pressure (IMPACT SENSOR in V) data for the resurgence phase of Model CSS-4
				CSS-5_RE	Time (in s), acceleration (X, Z in V) and pressure (IMPACT SENSOR in V) data for the resurgence phase of Model CSS-5
				CSS-6_RE	Time (in s), acceleration (X, Z in V) and pressure (IMPACT SENSOR in V) data for the resurgence phase of Model CSS-6
				CSS-7_RE	Time (in s), acceleration (X, Z in V) and pressure (IMPACT SENSOR in V) data for the resurgence phase of Model CSS-7
				CSS-8_RE	Time (in s), acceleration (X, Z in V) and pressure (IMPACT SENSOR in

					V) data for the resurgence phase of Model CSS-8
				CSS-9_RE (1, 2, 3)	Time (in s), acceleration (X, Z in V) and pressure (IMPACT SENSOR in V) data for the resurgence phase of Model CSS-9
	2025-071_ Sanchez-et-al_ **Matlab files**	This sub-folder contains the Matlab file for reading and plotting geophysical data	.mat .txt	Read_Data_ time_P_ACC	Matlab® script to read and plot the data acquired with the accelerometer and the impact sensors

Table 3. *File inventory of 2025-071_Sanchez-et-al_geophysical-data.*

6. Description of provided files for Analogue models

6.1. Movies and Photos of analogue model deformation

Movies (accelerated at 10× the original frame rate, supplied as .mp4 files) show the top-view evolution of model deformation (Fig. 2), and were created by editing high-resolution top-view photos (taken using a Canon EOS 1100D reflex camera and provided as .jpg files) acquired with 30 seconds time intervals. Photos are provided in grey-scale and can be used for Particle Image Velocimetry (PIV) analysis, line-drawings of structures and other applications.

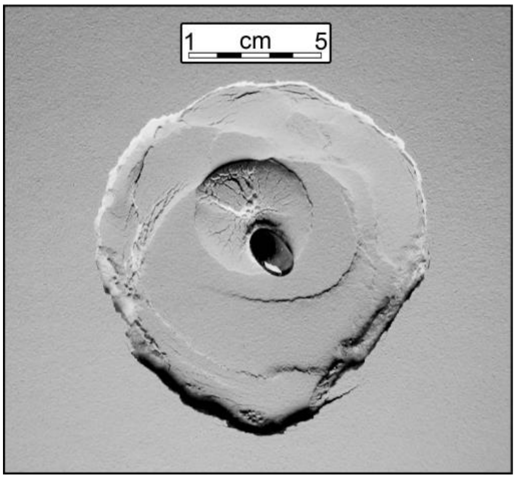

Figure 2. *Example of grey-scale top-view photo obtained for Model CSS-7 at the end of its deformation.*

6.2. 3D rendering of analogue models

We obtained three-dimensional rendering (Fig. 3) of different stages of analogue model deformation (provided as 3D .pdf files), basing on photogrammetric technique (e.g., Donnadieu et al., 2003) implementing Agisoft Metashape® software. Each 3D model was obtained by photogrammetric interpolation of a minimum of 16 and a maximum of 25 high-resolution photos (for models CSS-6 and CSS-4 and CSS-8, respectively) acquired with a Canon EOS 1300D reflex camera.

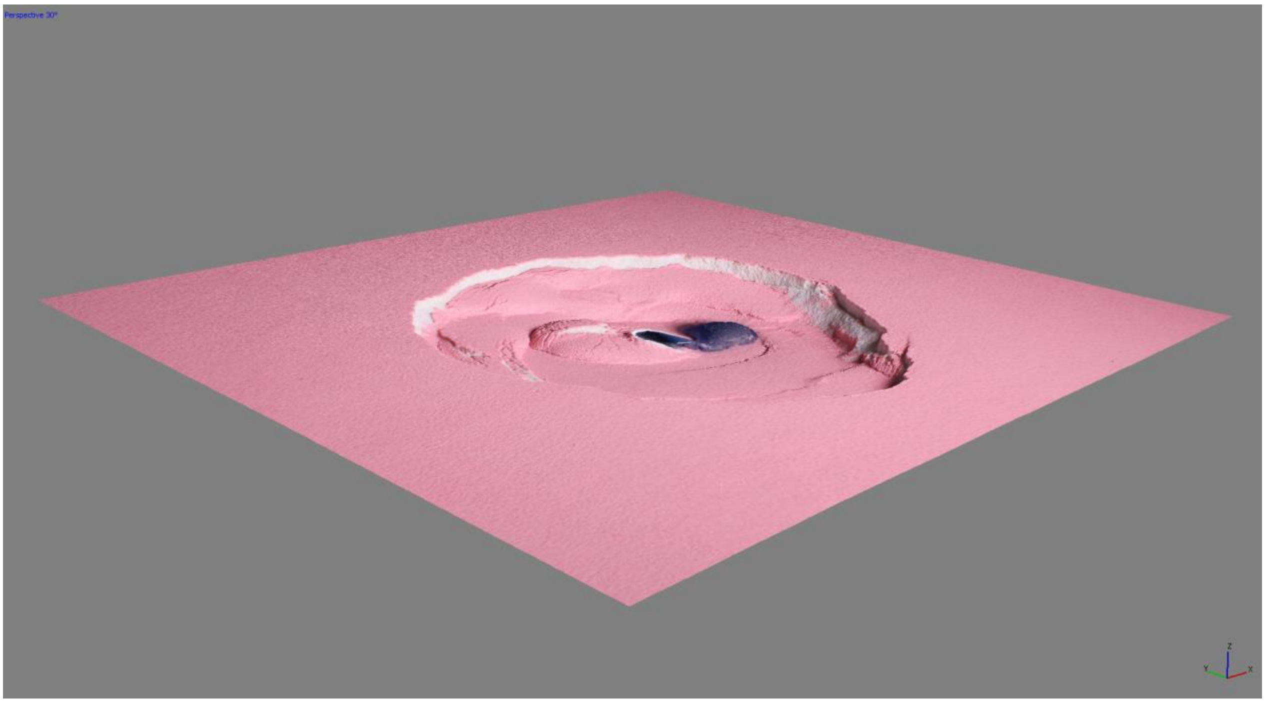

Figure 3. *Example (Model CSS-7) of 3D rendering obtained with Agisoft Metashape® software for the final stage (caldera resurgence) of model deformation.*

The procedure for 3D model elaboration is summarized below:

1. 3D perspective photo acquisition
2. photos upload, alignment and consequent genesis of the sparse cloud (tie points)
3. genesis of the dense cloud
4. local geo-referencing of markers
5. interpolation of model mesh
6. genesis of model texture
7. export of 3D pdf files with model rendering

3D .pdf of analogue models can be opened and viewed in any .pdf reader software e.g., Adobe Reader N.B., If this latter software is used, once opened, you may need to click on the centre and drag the 3D model to visualize it correctly.

6.3. DEMs of analogue models

We supply Digital Elevation Models (Fig. 4) (DEMs; generated as .tif files) for the final stage of analogue model deformation (post collapse deformation). We have acquired perspective photos of the models to build up a 3D rendering and the consequent interpolated DEM, following the procedure described above for the creation of 3D models through Metashape® and the protocol described in Maestrelli et al. (2020). DEMs were interpolated directly from the sparse cloud. The use of markers placed at fixed, and locally geo-referenced positions on the model setup allowed an easy and equal scaling of all obtained DEMs. The resulting DEM resolution varies between a maximum of 0.215 mm/pix for Model CSS-7 (obtained using 23 photos) and a minimum of 0.229 mm/pix for Model CSS-9 (obtained using 26 photos). DEMs files (.tif) can be opened with any Geographic Information System (GIS) software.

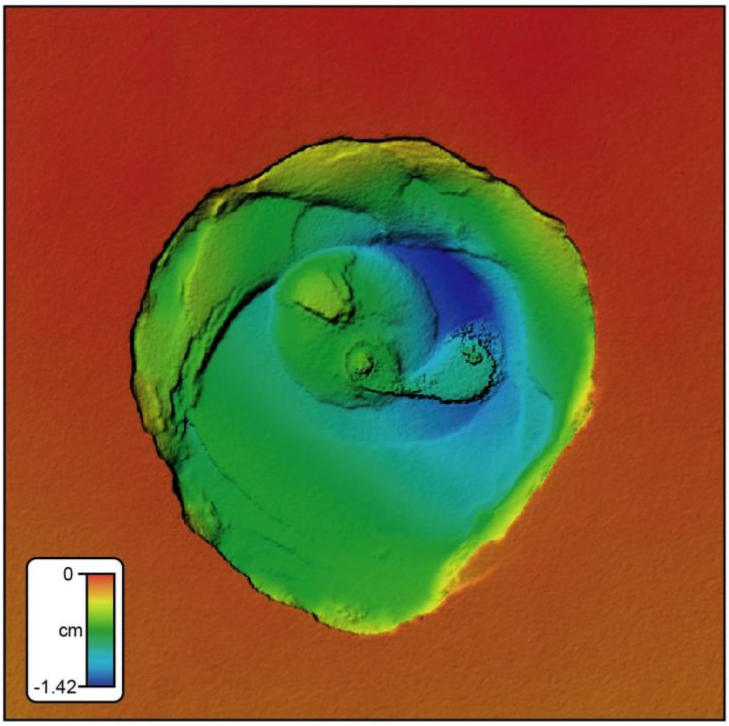

Figure 4. *Example (Model CSS-7) of Digital Elevation Model (DEM) generated with Agisoft Metashape® software.*

7. Description of provided geophysical data

For each analogue model, we provide geophysical data recorded during model deformation. Specifically, a PCB force sensor (Piezotronics PCB 104 200B02) connected to an amplifier (PCB 482A16), was placed inside the magma chamber to measure pressure during the experiment (Figure 1). Simultaneously, the acceleration during caldera collapse and resurgence was recorded using a triaxial piezoelectric accelerometer (Model 356B18), embedded within the granular material. Data acquisition was performed at a sampling rate of 5000 Hz using a Measurement Computing DAQ USB-1600 (16-bit) to guarantee precise synchronization of all measurements.

7.1. Accelerometer Data

We provide (.csv format files) the acceleration data in X (blue line) and Z (red line) directions (Fig.5), measured in Volts, acquired during model deformation using the triaxial piezoelectric accelerometer (Model 356B18). These data record the oscillatory response generated by deformation events in each model. The files can be opened and plotted with Matlab® software using the provided script (see section 7.3).

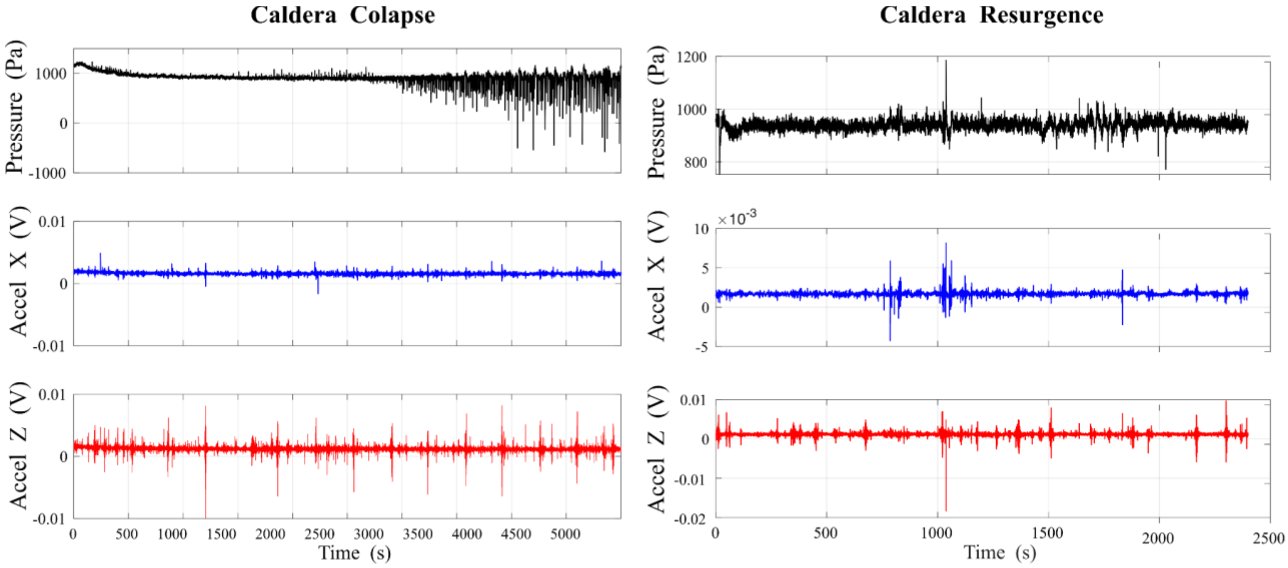

Figure 5. *Example of internal pressure (Pa) and X-Z accelerometer (V) data for Model CCS-7 for caldera collapse and caldera resurgence.*

7.2. Impact sensor data

We provide (.csv format files) the pressure data (black line measured in Pa, Fig. 5) with the Piezotronics PCB 104 200B02 (impact sensor). This file, which can be opened with Matlab® software, shows the pressure variation inside the magma chamber, as the collapse process proceeds. Data can be opened and plotted with Matlab® software using the provided script (see section 7.3).

7.3. Matlab® code for reading and plotting geophysical data

Together with the geophysical data, we provide the Matlab script (as .mat and .txt format files) to read and plot the data. The script plots the data acquired during model deformations time vs pressure/acceleration graphs.

```
%%%% READ DATA / PRESSURE / ACCELERATION

%----------------------------------------
% INITIAL CONFIGURATION
%----------------------------------------
csvFiles = dir('*.csv');
fs = 5000;              % SAMPLE [Hz]
windowSize = 10;        % SIZE window
cf_Volt_Pa = (88.96 / 0.000126);  % Conversion Volt - Pascal

% INITIAL VARIABLES
allX = [];
allZ = [];
allPressure = [];

%----------------------------------------
% READ DATA
%----------------------------------------
for k = 1:length(csvFiles)
    filename = csvFiles(k).name;
    try
        opts = detectImportOptions(filename, 'NumHeaderLines', 6, ...
                                   'Delimiter', '\t', ...
                                   'VariableNamingRule', 'preserve');

        data = readtable(filename, opts);
```

Figure 6. *Exemplificative figure showing part of the Matlab® script for reading and plotting the pressure and acceleration data for all the models.*

8. References

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