Analogue models of caldera resurgence: database of models and elaborations

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Additional information:

This dataset provides supporting information to "Bonini, M., Maestrelli, D., Corti, G., Del Ventisette, C., Moratti, G., Carrasco-Núñez, G., Giordano, G., Lucci, F., Norini, G., Piccardi, L., Urbani, S., Montanari, D. (Submitted). *Modelling intra-caldera resurgence settings: Laboratory experiments with application to the Los Humeros geothermal field Mexico.*

The models and the derived data have been elaborated at the *Tectonic Modelling Laboratory* of CNR-IGG and University of Florence, Italy.

1. Dataset description

This dataset presents the results of an experimental series of analogue models performed to investigate caldera resurgence processes, particularly the setting of the Los Potreros caldera that belongs to the Los Humeros Volcanic Complex (Puebla State, Mexico). Our experimental series was designed adopting a parametric approach, which consisted in the systematic variation of controlling parameters, such as: depth of intrusion, overburden thickness above the analogue magma chamber, presence of inherited discontinuities. Structures of models have been analysed quantitatively by means of (i) photogrammetric Digital Elevation Model reconstruction, (ii) semi-automatic fault pattern quantification and (iii) Digital Particle Image Velocimetry techniques. In this dataset, we show the row data and specific elaborations supporting the interpretation of modelling results.

2. List of supplied files

In this dataset, we provide the following type of data:

- a separate synthetic list of provided files.
- movies obtained from high-resolution top-view photos acquired during caldera collapse and caldera resurgence.
- input files for FracPaQ software used for semi-automatic fault pattern quantification.
- Digital Elevation Models (DEMs) of caldera collapse and caldera resurgence.
- Digital Elevation Models (DEMs) of topographic difference between caldera resurgence and caldera collapse.
- fully navigable 3D pdf files of the final fault pattern of caldera collapse and caldera resurgence.
- movies obtained from PIVlab software recording DPIV analysis on target models

3. Description of provided files

3.1. Movies of model deformation

Movies (supplied as .mp4 files) show the top-view evolution of model deformation, and were created by editing high-resolution top-view photos (taken using a Canon EOS 1100D reflex camera) acquired with 120 seconds time intervals. Separate movies are provided both for caldera collapse and caldera resurgence stages of model deformation.

3.2. Input files FracPaQ

We supply the input file (Fig.1) (.svg format) for FracPaQ Software (Healy et al., 2017). This software can be freely downloaded at http://davehealy-aberdeen.github.io/FracPaQ/, and can be run under MATLAB™. Each input file reports the digitized structural pattern of the resurgent area of target models, and can be used to quantitatively determine fracture density. Models were digitized through Adobe Illustrator® software at the same magnification in order to avoid data bias.

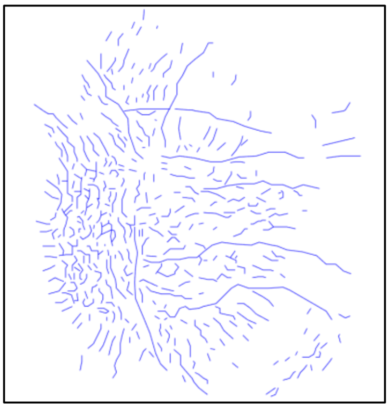

Figure 1. Example (Model LR-02) of input file generated for quantitative analysis of faults to be elaborated by FracPaQ software (Healy et al., 2017).

3.3. 3D Models

We obtained three-dimensional rendering (Fig. 2) for caldera collapse and caldera resurgence stages (provided as 3D .pdf files), basing on photogrammetric technique (e.g., Donnadieu et al., 2003) implementing Agisoft Photoscan® software. Each 3D model was obtained by photogrammetric interpolation of a minimum of 10 and a maximum of 19 high-resolution photos (acquired with a Canon EOS 1300D reflex camera).

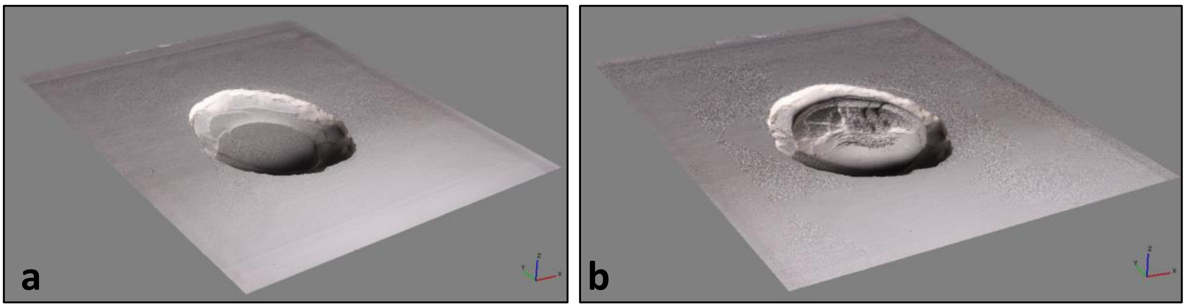

Figure 2. Example (Model LR-02) of 3D rendering obtained with Agisoft Photoscan® software for (a) caldera collapse and (b) caldera resurgence stages.

The procedure for 3D model elaboration is summarized below:

- 3D perspective photo acquisition
- photos upload, alignment and consequent genesis of the sparse cloud (tie points)
- genesis of the dense cloud
- interpolation of model mesh
- genesis of model texture
- export of 3D pdf files with model rendering

3.4. DEMs

We supply Digital Elevation Models (Fig. 3) (DEMs; generated as .tif files) for both caldera collapse and caldera resurgence stages of models. 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 Photoscan®. 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. DEM resolution ranges from a minimum of 0.356 mm/pix (Model PR-02_Collapse) to a maximum of 0.152 mm/pix (Model LR-02_Resurgence), with an average resolution of 0.251 mm/pix.

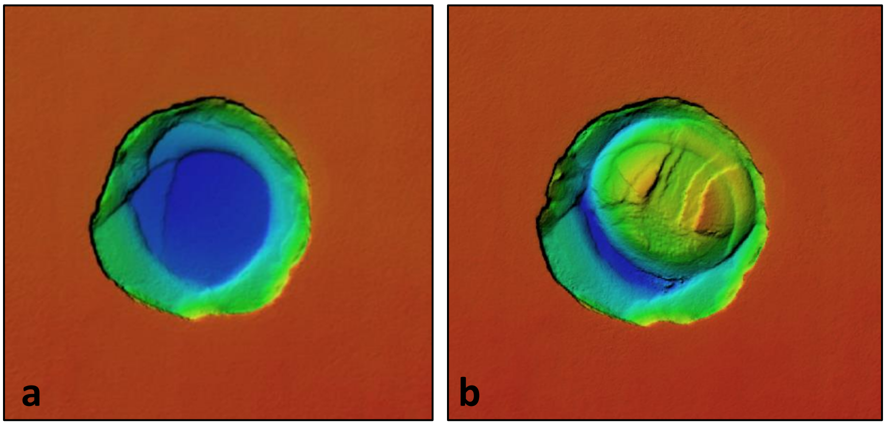

Figure 3. Example (Model LR-02) of Digital Elevation Model (DEM) generated with Agisoft Photoscan® software for (a) caldera collapse and (b) caldera resurgence stages.

3.5. Digital Particle Image Velocimetry analysis

Digital Particle Image Velocimetry (DPIV) analysis was performed on target models to evaluate the horizontal displacement by correlating couples of top view images (Fig. 4). The analysis was performed using the PIVlab software (Thielicke and Stamhuis, 2014), which is freely downloaded at https://www.mathworks.com/matlabcentral/fileexchange/27659-pivlab-particle-image-velocime try-piv-tool.

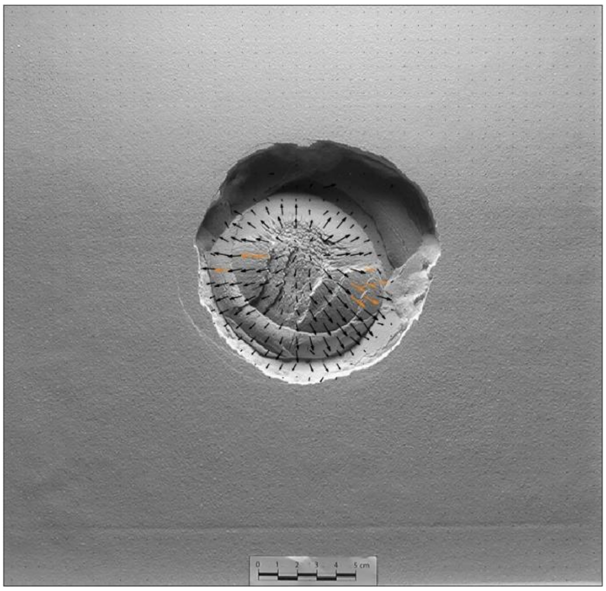

Figure 4. Example (Model LR-02) showing the displacement vectors for a target frame calculated with PIVlab. Valid vectors (black) and interpolated vectors (orange) are shown. N.B. The software allows also for the calculation of other derivative parameters.

We recorded movies of the DPIV analysis (provided as .mp4 files showing displacement vectors) performed on top-view photos according to the following settings:

- **Search window parameters:**

Pass 1: Interrogation area: 64 pixel

Step: 32 pixel

Pass 2: Interrogation area: 32 pixel

Step: 16 pixel

Pass 3: Interrogation area: 16 pixel

Step: 8 pixel

- **PIV algorithm:** FFT window deformation
- **Window deformation interpolator:** Linear
- **Sub-pixel estimator:** Gauss 2x3-point

The choice of the time steps between frames for the DPIV analysis depends on the velocity of model deformation, and can therefore change depending on the model. The adopted time steps for the DPIV analysis are reported in Table 1.

Model name	Adopted time steps between frames (s)
LR-01	600
LR-02	360
LR-03	120
LR-04	120
PR-01	600
PR-02	600
DR-01	360
DR-02	120

Table 1. Adopted time steps (in seconds) for the DPIV analysis of target models.

4. References

Donnadieu, F., Kelfoun, K., de Vries, B. V. W., Cecchi, E., & Merle, O. (2003). Digital photogrammetry as a tool in analogue modelling: applications to volcano instability. *Journal of Volcanology and Geothermal Research*, *123(1-2)*, 161-180. https://doi.org/10.1016/S0377-0273(03)00034-9

Healy, D., Rizzo, R. E., Cornwell, D. G., Farrell, N. J., Watkins, H., Timms, N. E., ... & Smith, M. (2017). FracPaQ: A MATLAB™ toolbox for the quantification of fracture patterns. *Journal of Structural Geology*, *95*, 1-16. https://doi.org/10.1016/j.jsg.2016.12.003

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