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## Data Article

# More than eleven years of temperature and displacements recorded on and in a limestone cliff: Dataset



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## ABSTRACT

This data set gives more than 11 years of temperature and displacements recorded on and in a limestone cliff. An extensive presentation of the monitoring devices and interpretation of data is proposed in Gasc-Barbier et al. (2021) [1]. The hazard-monitored zone is a perched cave in a limestone cliff where a part of its roof had collapsed. On its roof, an unstable beam reminds. A horizontal interlayer thinning from East to West, hanging to the roof of the cave at the west and east-clamped in the rock mass, delimits this remaining beam. Opened fractures can be observed all around the beam. In order to assess the remaining hazard, four fissurometers (F1 to F4) and a thermal probe were installed on the roof of the cave and two borehole extensometers (D1 and D2) were drilled perpendicular to the face of the cliff, above the cave, to understand the global behaviour of the rock mass. Measurements have been made between sockets embedded in the rock mass by means of INVAR wire measurements. Four bases made of two sockets each have been installed inside the cavity and five were put on the face of the cliff outside and above the cavity. Measurements last between January 2011 and June 2021. A 1.5-year gap is observed in the measurements because they were temporally stopped when

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reinforcement works were preceded carried out in the cave in order to secure the village.

Thus, datasets provide more than 11 years of temperature and displacements recorded on and in the cliff, providing insight on the relation between climate and the deformation inside the rock mass. This dataset is novel because this type of data is not readily available in the literature, on the one hand, because of its length (nearly 11 years) and, on the other hand, because it is not only surface evolution of temperature and aperture but because the evolution of temperature and deformation inside the rock mass was monitored. Researchers could use these data for a better understanding of the thermomechanical coupling in rock. They could test their own modelling, constitutive laws specifically on crack propagation or thermal fatigue.

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## Specifications Table

Subject	Geotechnical Engineering and Engineering Geology
Specific subject area	11 years of climate - displacement interactions were recorded on a natural limestone cliff: aperture of joints and displacements at 2 m, 4 m, and 6 m depth from the face of the cliff.
Type of data	Tables Figures Graphs
How data were acquired	Joint aperture is measured with LVDT strain gauges (called fissurometers – see Fig. 3 upper left in Gasc-Barbier et al. [1]) that measure displacements between their two extremes (resolution: 1/100th mm). INVAR wire measurement with Invar wires calibration by interferometry – See Gervaise, J. [2]. Temperature in the cave is measured by a thermal probe (resolution: 1/100th°C) In the rock mass, measurements were realised with borehole extensometers (RockTest / Télémac distofo <sup>TM</sup> ) with 3 measurement points at 2, 4 and 6 m depth.
Data format	Raw
Parameters for data collection	Data were acquired automatically each hour of the day during nearly eleven years except for few periods during which no data were recorded.
Description of data collection	INVAR wires: Nearly two measures per year have been registered. Fissurometer data (joint aperture) were collected to monitor the remaining hazard after the collapse of a part of the roof of a perched cave in a limestone cliff whereas borehole extensometers were collected to understand the global behaviour of the limestone cliff. The analysis of the data shows no drift, or the drift is largely lower to the measured displacements. 21 INVAR wire bases measurements show the outside deformation of the strates of the cliff
Data source location	City/Town/Region: La Roque-Gageac / Occitanie Country: France Latitude and longitude (and GPS coordinates, if possible) for collected samples/data: 44.82642N, 1.182463E
Data accessibility	Repository name: Mendeley Data Data identification number: <a href="https://data.mendeley.com/datasets/wnt6thwzvp.2">10.17632/wnt6thwzvp.2</a> Direct URL to data: <a href="https://data.mendeley.com/datasets/wnt6thwzvp.2">https://data.mendeley.com/datasets/wnt6thwzvp.2</a>
Related research article	Gasc-Barbier et al. [1] The role of natural thermal cycles on a limestone cliff mechanical behavior. <i>Engineering Geology</i> . DOI <a href="https://doi.org/10.1016/j.enggeo.2021.106293">10.1016/j.enggeo.2021.106293</a>

## Value of the Data

- This dataset is almost the only one that enables to monitor together temperature and displacement during nearly eleven years, simultaneously at the surface of a rock mass (aperture of joints) and in the rock mass at 2 m, 4 m and 6 m depth from the surface of a natural cliff.
- Researchers can use these data to better understand the thermomechanical coupling in a jointed natural rock mass.
- Researchers will be able to test their own modelling, constitutive laws and, specifically, crack propagation or thermal fatigue when very few data are available nowadays.
- Prospective of evolution of rock hazard and evaluation of the delay to a future rock mass collapse

## 1. Data Description

The hazard-monitored zone is a perched cave in a limestone cliff where a part of its roof had collapsed. The cliff is above a small but very touristic French village: La Roque-Gageac. Fig. 3 in Gasc-Barbier et al. [1] is a front view picture that displays the hazard-monitored zone, and Fig. 4 (ibidem) proposed a schematic cross-section of the cliff with the instrumented perched cave.

On those two figures, the limestone cliff with its perched cave and its partially collapsed roof are displayed. On the roof, an unstable beam reminds. A horizontal interlayer thinning from East to West, hanging to the roof of the cave at the west and east-clamped in the rock mass, delimits this remaining beam. Opened fractures can be observed all around the beam. In order to assess the remaining hazard, four fissurometers (F1 to F4) and a thermal probe were installed on the roof of the cave and two borehole extensometers (D1 and D2) were drilled perpendicular to the face of the cliff, above the cave, to understand the global behaviour of the rock mass. As it can be noticed in the two previous figures, open fractures are more or less horizontal and vertical. The vertical ones are parallel to the face of the cliff and are probably decompression fractures and the horizontal ones are sedimentary layers.

### 1.1. File *LaRG20102021\_fissurometer*

The four fissurometers were positioned around the remaining beam to quantify the aperture of the joints, in order to evaluate the relative movement of the blocks, according to changes in external conditions: F1 near the east-clamped end of the beam, and the three others on the west part: Two of them (F3 and F4) were fixed across a horizontal joint and a vertical joint respectively, F2 is positioned across the vertical joint in a 45° angle. The thermal probe was fixed on the roof of the cavity near the three. Fissurometers are LVDT (Linear Variable differential transformer (used in tension)) strain gauges that measure displacements between their two extremes with a resolution of 1/100th mm. *DATA-fissuromètres.csv* gives the aperture of the joints measured with the 4 fissurometers and temperature measured in the cave with the thermal probe recorded during the whole period (one measurement point per hour). Columns are “time; F1 to F4 recorded displacement (mm); temperature (°C)”.

### 1.2. File *LaRG20102021\_disto*

The borehole extensometers (D1 & D2) are RockTest / Télémac distoform<sup>TM</sup> anchored in the rock mass at the end of the borehole at a depth of 8 m from the cliff wall. Both were prepared by the manufacturer with three displacement-measuring points at depths of 2 m, 4 m and 6 m (see attached leaflet) from the cliff wall and temperature measuring points at 2 m and 6 m depth. The supplier gives a measuring range of 100 mm, a resolution lower than 0.01 mm. Given



**Fig. 1.** Installation of borehole extensometer in pre-drilled borehole.

the length of the rods used (8 m), the precision is about 0.05 mm. The operating temperature must remain between 0° and 50°C. The devices were placed acrobatically (Fig. 1), perpendicular to the rock face, about 4 m and 7.5 m above the roof of the cave cavity. Before that, boreholes were also drilled acrobatically. DATA-extenso.xlsx gives in the same table all data recorded with both borehole extensometers, 1 measurement point per hour. Columns are “time; displacements (mm) in D1 at 6, 4 and 2m depth, then in D2 at 6, 4 and 2m depth, temperature (°C) in D1 at 6 and 2m depth, then in D2 at 6 and 2m depth”.

### 1.3. File LaRG20102021\_Invar

The 21 measurements made of the length between sockets in the cavity or on the face of the cliff are shown. Around two measurements have been done per year. The invar wires set and measuring device are calibrated every two year by interferometry.

## 2. Experimental Design, Materials and Methods

In the morning of January 8th, 2010, a part of the roof of a perched cave collapsed above the small village of La Roque-Gageac. This cave was used in the Middle Ages as a small stronghold for the Bishop of Sarlat during the religious wars. No instrumentation was on site at the time and no obvious triggering factor could be involved (no rain, no seismic event, no frost). Geotechnical Cerema experts were called to evaluate the remaining hazard and to propose remediation works. As no other triggering factor could be demonstrated, temperature variations were suspected. We proposed to monitor the temperature and the displacement on specific joints on both ends of the remaining beam (with jointmeter) and also in the rock mass (with distometers). Different aims were targeted: survey the remaining hazard and design the reinforcement in one hand and understand the mechanism that can induce such collapse in the other hand.

The data have been acquired automatically each hour of the day. The sensors either for displacement in borehole or outside on the cliff are based on the LVDT technology (LVDT: Linear Variable differential transformer (used in tension). Those sensors have been calibrated prior to their setup. The LVDT technology has been chosen for its performance and reliability in harsh situations. Those sensors are without contact, they are not prone to wear. The analysis of the data showed no drift, or the drift is largely inferior to the measured displacements.

The temperature sensors in use are PT 100 (class A), they are known to give the best precision in this range of temperature (−20° C – 200°C).

The sensors were chosen due to their time stability, robustness and precision.

The Invar wire used to measure the length between sockets are calibrated every two year by interferometry [2].

## Ethics Statement

The authors declare that this submission follows the ethical requirements for publication in Data in Brief.

Annexe 1: Package leaflet “distor\_v2.pdf”(in French/English)

## CRediT Author Statement

**Didier Virely:** Data curation, Methodology, Investigation; **Muriel Gasc-Barbier:** Supervision, Writing – original draft, Writing – review & editing; **Véronique Merrien-Soukatchoff:** Conceptualization, Visualization, Validation.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have or could be perceived to have influenced the work reported in this article.

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## Supplementary Materials

Supplementary material associated with this article can be found in the online version at doi:[10.1016/j.dib.2021.107568](https://doi.org/10.1016/j.dib.2021.107568).

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- [1] M. Gasc-Barbier, V. Merrien-Soukatchoff, D. Virely, The role of natural thermal cycles on a limestone cliff mechanical behavior, *Eng. Geol.* (2021) DOI [10.1016/j.enggeo.2021.106293](https://doi.org/10.1016/j.enggeo.2021.106293).
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