SUPPLEMENTARY MATERIAL

EXPERIMENTAL SETUP

The experimental apparatus consists of a large cylindrical tank, with a diameter of 1 m and a height of 1.4 m (Figure S1a). The tank is filled with brown sand. A water-filled bladder is placed in the center of the tank and carefully levelled. It is connected to a pump via a hose going downward, through a hole at the bottom of the tank. We add brown sand until only the top of the bladder is exposed. From this point, we add brown sand layer by layer. Each layer is about 1 cm thick. We compact each layer with a wooden board to limit pore space and increase sand cohesion. A thin layer of white industrial quartz (sandblasting sand) is added between each layer of brown sand as a colour marker; this serves to trace faults after the experiment.

The electronic sensors are carefully placed between two layers of brown sand, halfway between the top of the magma chamber and the surface at a depth of 3.5 cm (Figure S2b). Cables connecting the sensors are carefully levelled and taped to the edge of the tank to avoid disturbing faulting processes. The sensors are arranged in a line (Figure S2) and labelled “east”, “center” and “west”, respectively.

PIEZOELECTRIC SENSORS

We used piezoelectric sensors to monitor our apparatus (Figure S1b). The sensors are produced by Phidgets Inc. (Phidgets 1104_0 – Vibration sensors). Each sensor features a piezoelectric transducer, which transforms mechanical strain into an electric signal. This analog input is then transmitted to a computer through an analog-to-digital converter (Phidgets 1018_2 - PhidgetInterfaceKit 8/8/8) with a sampling frequency of 49 Hz. Hence, we obtain a time series of the local stress state around each sensor.
The sensitivity of the sensors falls off steeply with distance. The sensors generally record changes occurring within a radius of ~2 cm, although this value depends on the amplitude of the event considered.

The values outputted by the sensors are not calibrated, in the sense that it is impossible to relate these values to real stresses. This is why the time series are presented with arbitrary units (a.u.). However, all sensors are calibrated with respect to each other; for instance, a change of 20 a.u. in the centre sensor data is equivalent to a change of 20 a.u. in the west centre. The calibration also holds between different experiments, i.e., the values recorded in experiment A can be compared directly to those from experiment B.

DATA ANALYSIS

Spectrograms

Figure S3 and S4 show spectrograms associated with each sensor signal for experiment A and B, respectively. Each spectrogram presents the time evolution of the frequency power spectrum. The spectrograms are computed via the short-time Fourier Transform of a moving window, containing 130 data points for experiment A (i.e. 2.6 seconds) and 400 data points for experiment B (i.e. 8.2 seconds). All spectrograms corroborate the observations of the stress signal given in the main text.

In experiment A, the frequency spectrum of all sensors is steady and restricted to low frequencies (<3 Hz, Figure S3) during the first twenty seconds. The first significant change occurs in the centre sensor signal at about 20 seconds. Here, there is a sudden increase in the range of frequencies (0-25 Hz). There is also an important increase in the intensity of lower frequencies. This is followed by a rapid decrease of the frequency range (0-15 Hz at 27 seconds). The frequency range then steadily decays back until the end of the experiment. This first event corresponds to the first very large drop observed in the stress signal, which we
identify to be related to the formation of the first inner faults. The east and west spectrograms stay steady until about 70 and 120 seconds, respectively. At 70 seconds, the east spectrogram features a gradual increase in the range of frequencies, as well as a slight increase of the lower frequencies’ intensity. The period of high frequency range is sustained for a longer period than for the centre sensor. The east sensor frequency range then slowly decreases to 0-8 Hz, i.e., above background level, before the experiment is terminated. At 120 seconds, the west spectrogram displays a similar pattern, i.e., a gradual increase in frequency range and a slight increase of the lower frequencies’ power. The experiment ends while the frequency range of the west sensor signal is still high. For both the east and west sensors, the aforementioned spectrogram features happen at similar times as fault nucleate at the surface.

Concerning experiment B (Figure S4), the background level comprises frequencies between 0-3 Hz. The first significant deviations from background occur in the centre spectrogram at about 75 seconds. Here, we see a sudden increase in the range of frequencies (0-17 Hz). This increases steadily to a maximum 0-24.5 Hz around 180 seconds (i.e., the maximum frequency our sensors can record). It then steeply decays back to background level, where it stays until the end of the experiment. The west spectrogram displays some interesting features starting at 500 seconds. The frequency range increases to 0-10 Hz. It then fluctuates between 0-5 Hz and 0-10 Hz until the experiment is terminated. Finally, the east spectrogram does not display much perturbation from background level, although a slight increase in frequency range occurs during the last minute of the experiment. The patterns observed in these three spectrograms are in agreement with the analysis of the stress signals. The timing of the large variations observed in the range of frequencies concurs very well with visual observations of faults forming at the surface.
Our frequency spectrum analysis of the sensor stress signal supports our hypothesis that structures observed in the stress output can be related to faulting processes. In term of frequencies, fault nucleation involves an increase in frequency range and power.

**Inner faults vs. outer faults**

We present close-up views of the important features from Figure 1 in the main text. Figure S5 focuses on experiment A whereas Figure S6 is concerned with experiment B.

Figure S5 presents the stress data from (a) the centre sensor when the first fault appears, (b) the east sensor when the eastern outer fault appears and (c) the west sensor when the western fault appears. The stress signals are very different between the first inner fault (a) on one hand and the outer faults (b and c) on the other hand. The signal from the centre sensor in Figure S5a features a large, abrupt drop, reaching a minimum two seconds before the first fault appears at the surface. The signals in Figure S5b and S5c are qualitatively and quantitatively similar. There is no deviation from the background signal before the outer faults appear. Once the faults are observed on the surface, the signal peak-to-peak amplitude gradually increases from ~5 a.u. to ~20 a.u. The duration of the event recorded by the east sensor signal is longer than the one from the west sensor; this is because the experiment was manually stopped after 150 s, putting an end to faulting activity. The stress output therefore strongly contrasts between inner and outer faults.

It is worth noting that this dichotomy can also be observed in the spectrograms (Figure S3). The centre sensor displays a sharper increase and a more rapid decrease in frequency range, as well as higher intensity for lower frequencies. On the other hand, the east and west sensors exhibit more gradual and less powerful but more sustained spectrograms.

The trends observed in experiment B are similar to the trends in experiment A. Figure S6 contains the stress evolution from (a) the centre sensor while the first fault appears and (b)
the west sensor when the western outer fault appears. The signal in Figure S6a resembles the signal in Figure S5a. It is characterized by a sharp drop, preceding the appearance of the first fault by 17 s. The amplitude of the deviations increases after this first drop. We can then observe a positive peak, followed by a slow decrease back to background level. Similarly, Figure S6b is comparable to Figure S5b and S5c, though less striking. The stress pattern shows no deviation before the outer fault appears but features a gradual increase in peak-to-peak amplitude, from 2 a.u. to 15 a.u., once the fault has appeared on the surface. As for experiment A, the differences observed between inner and outer fault in the stress signal are also visible in the spectrograms (Figure S4).

**DIRECTION OF FAULT PROPAGATION**

Here, we support our claim that outer faults propagate downwards whereas inner faults propagate upwards. We present results for one outer fault and one inner fault; however, the analysis holds for all faults.

We focus on the left-hand side of the cross section from Figure 2B in the main text. Using the white sand markers, we can measure the displacement accommodated by the fault at three different depths: close to the surface, close to the magma chamber, and halfway in between. We highlight the white sand markers on each side of the fault, using a color code (Figure S7). The displacement on the fault is indicated at each depth. The outer fault displays progressively less displacement with depth, indicating downward propagation. By contrast, the inner fault accommodated more displacement at depth, suggesting an upward propagation.

**FIGURE CAPTIONS**
Figure S1: (a) Diagram of the experimental setup. A 1 m diameter cylinder is filled with dry sand. A rubber bladder, filled with water, is buried and connected to a pump. A flowmeter is used to control the flow out of the bladder. A camera is set up above the cylinder to record surface deformation. Sensors are placed halfway between the bladder and the surface. Sensor input is recorded on a computer through an analog to digital converter. (b) A piezoelectric sensor, from Phidgets Inc.

Figure S2: (a) Location of the three sensors during our experiments, viewed from above. (b) The sensors being placed during the preparation of an experiment.

Figure S3: Spectrograms from experiment A. The stress signal from each sensor is presented on top. The cyan rectangles represent periods of fault nucleation at the surface (see main text). The bottom graphs are spectrograms, representing the time evolution of the frequency power spectrum.

Figure S4: Spectrograms from experiment B. The stress signal from each sensor is presented on top. The cyan rectangles represent periods of fault nucleation at the surface (see main text). The bottom graphs are spectrograms, representing the time evolution of the frequency power spectrum.

Figure S5: Stress evolution during experiment A. Fault appearance is indicated by cyan rectangles. (a) Centre sensor when the first fault appears. (b) East sensor when the eastern outer fault appears. (c) West sensor when the western outer fault appears.

Figure S6: Stress evolution during experiment B. Fault appearance is indicated by cyan rectangles. (a) Centre sensor when the first fault appears. (b) West sensor when the eastern outer fault appears.

Figure S7: Cross section of experiment A. One outer fault (left) and one inner fault (right) are highlighted. White sand markers are also highlighted to show fault displacement. Fault
displacement is measured using graphics software and indicated next to the corresponding arrow.
Figure S1

(a)

(b)
Figure S4

(a) West

(b) Centre

(c) East