COMET Event Response

Area of Interest: Fentale Volcano, Ethiopia
Date Covered: 10 – 25 January 2025
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Data Used:

- InSAR images collected by the European Sentinel-1 satellite and processed using the COMET LICSAR system (https://comet.nerc.ac.uk/comet-lics-portal/)
- InSAR images acquired by the COSMO-SkyMed (CSK) satellites, provided through the CEOS GVEWERS programme and processed at the University of Bristol using GAMMA.
- USGS Earthquake Catalogue (https://earthquake.usgs.gov/earthquakes/search/)

Recent Activity:

Slowing deformation

Sentinel-1 and COSMO-SkyMed (CSK) interferograms show continued unrest and deformation, with a slower rate of deformation. The latest 12-day descending Sentinel-1 interferogram suggests that the rate of subsidence at Fentale and dyke opening have slowed when compared to the previous 12-day interferogram. Line-of-sight (LOS) displacement away from the satellite at Fentale decreased from ~45 cm during 29 Dec 2024 – 10 Jan 2025 to ~33 cm during 10-22 Jan 2025. Deformation associated with dyke opening has also decreased, from > 1m in the previous 12-day period, to > 65 cm in the most recent 12-day period (Fig 1). The dyke has neither propagated further northwards, nor is there a change in propagation direction. The USGS reported 34 M4.0-5.2 earthquakes from 10-22 January.

Ascending and descending CSK interferograms with identical temporal baselines (8-day descending and 1-day ascending) also suggests a slowing deformation at Fentale and dyke opening (Fig 2). From the 8-day descending images, the LOS displacement away from the satellite at Fentale decreased from > 25 cm (7-15 Jan) to > 11 cm (15-23 Jan) (Fig 2a-b). The 1-day ascending images show a decrease in deformation related to dyke opening from ~12 cm LOS displacement from 8-9 Jan to ~3 cm from 24-25 Jan (Fig 2c, f). The dyke opening is now localised to the northern segment, with the length of the dyke opening decreasing from ~ 35 km to ~13 km, from the most recent 1-day interferogram (Fig 2e-f).

Change in deformation patterns at Fentale

Subsidence at Fentale is ongoing, but the deformation pattern is changing based on consecutive CSK interferograms (Fig 3). Earlier on during the December 2024 unrest, a simple deflating source beneath Fentale might be able to explain majority of the deformation. However, more recent deformation patterns suggests that additional sources are required. The latest images point towards the likelihood of several NE-SW trending linear features (possibly faults and/or dykes) located north and northeast of Fentale that are increasingly dominating the deformation signal (Fig 3 b-c, e-f). Significant influence from slip along caldera ring faults is unlikely (Fig 4).

Modelling

Preliminary models of a ~ 55 km long segmented dyke, 2 normal graben faults on either side of the dyke and a deflating mogi source beneath Fentale show a reasonable fit to the general displacement patterns of ascending and descending Sentinel-1 interferograms. Model estimates of maximum dyke opening, total dyke volume and mogi deflation volume correlate with the slowdown in activity during the most recent 12-day period of 10-22 January (Fig 5a).

Forward Look:

Activity is ongoing, with 7 M4.4-4.9 earthquakes reported by USGS from 22-25 January. Thermal anomalies and plumes have been observed at Fentale from infrared (MIROVA detections of hotspots from MODIS sensors) and optical (e.g., Sentinel-2) satellites since mid-January.

We will continue to monitor surface deformation with the upcoming Sentinel-1 and COSMO-SkyMed images. This, in combination with other data, observations and models, will provide evidence on which the potential evolution of the event can be considered. A scientific committee comprising scientists from Addis Ababa University (IGSSA and School of Earth Science), the Geological Institute of Ethiopia and other relevant institutions is monitoring the events and keeping the Ethiopian Disaster Risk Management Commission (EDRMC) and the public continuously informed. The government has reminded citizens to follow precautionary messages given by professionals.

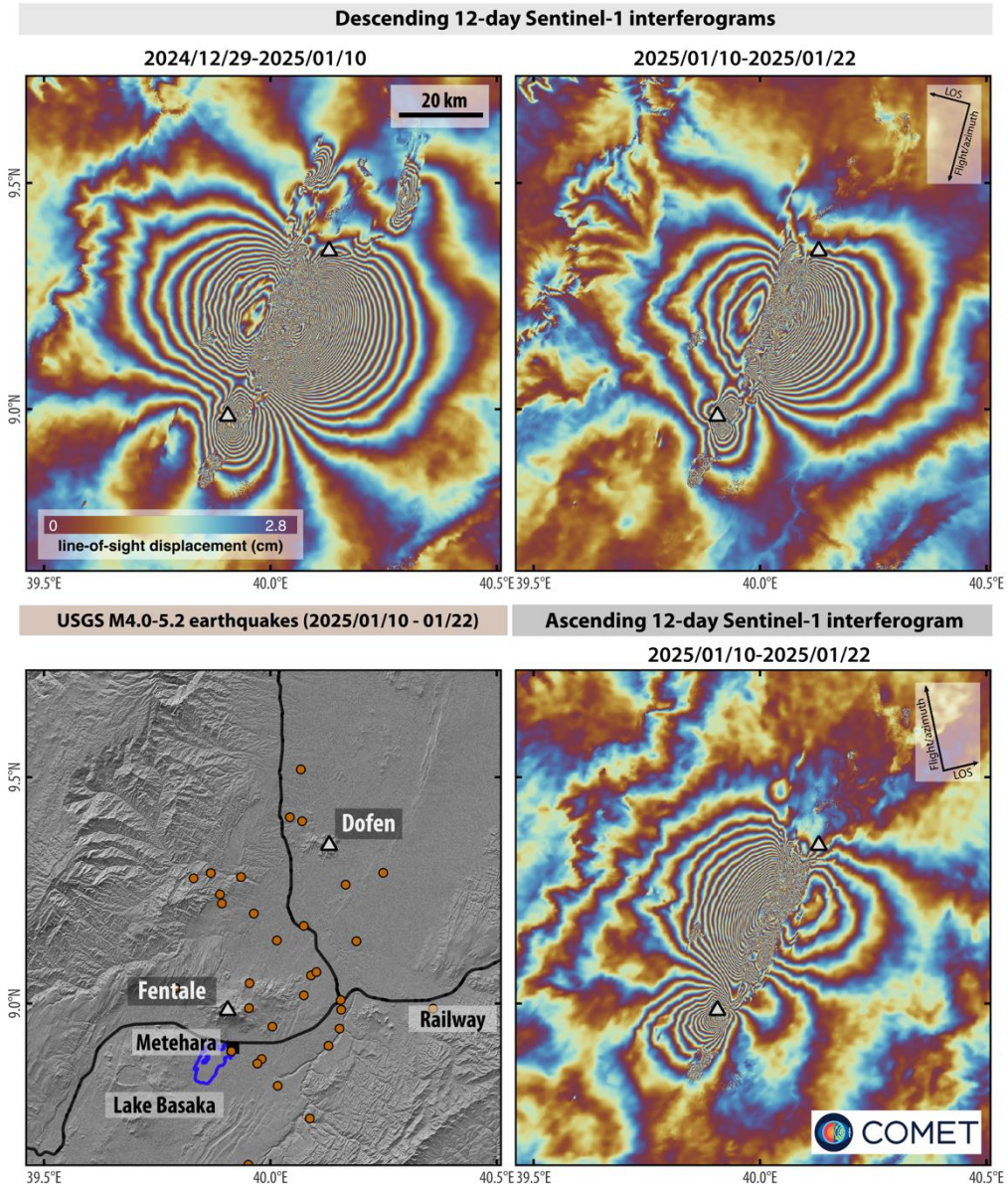

Fig 1. 12-day Sentinel-1 interferograms showing a decrease in deformation rate at Fentale and dyke opening during the latest 12-day period from 10-22 January, compared to the previous 12-day period from 29 December to 10 January.

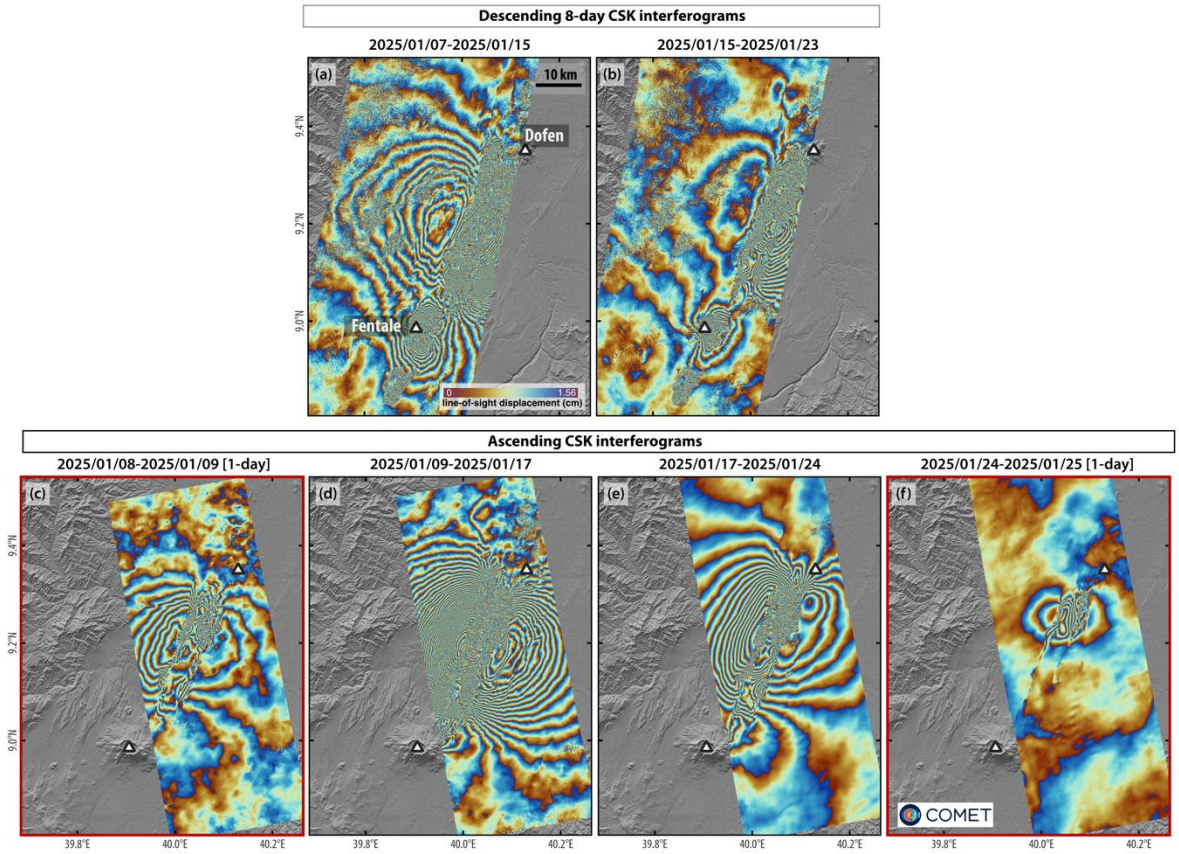

Fig 2. 8-day descending CSK interferograms (a-b) and 1-day ascending interferograms (c,f with red borders) showing a slowdown in dyke opening as well as subsidence at Fentale. The most recent 1-day interferogram (f) shows that the dike opening is now localised within the northern segment, just south of Dofen.

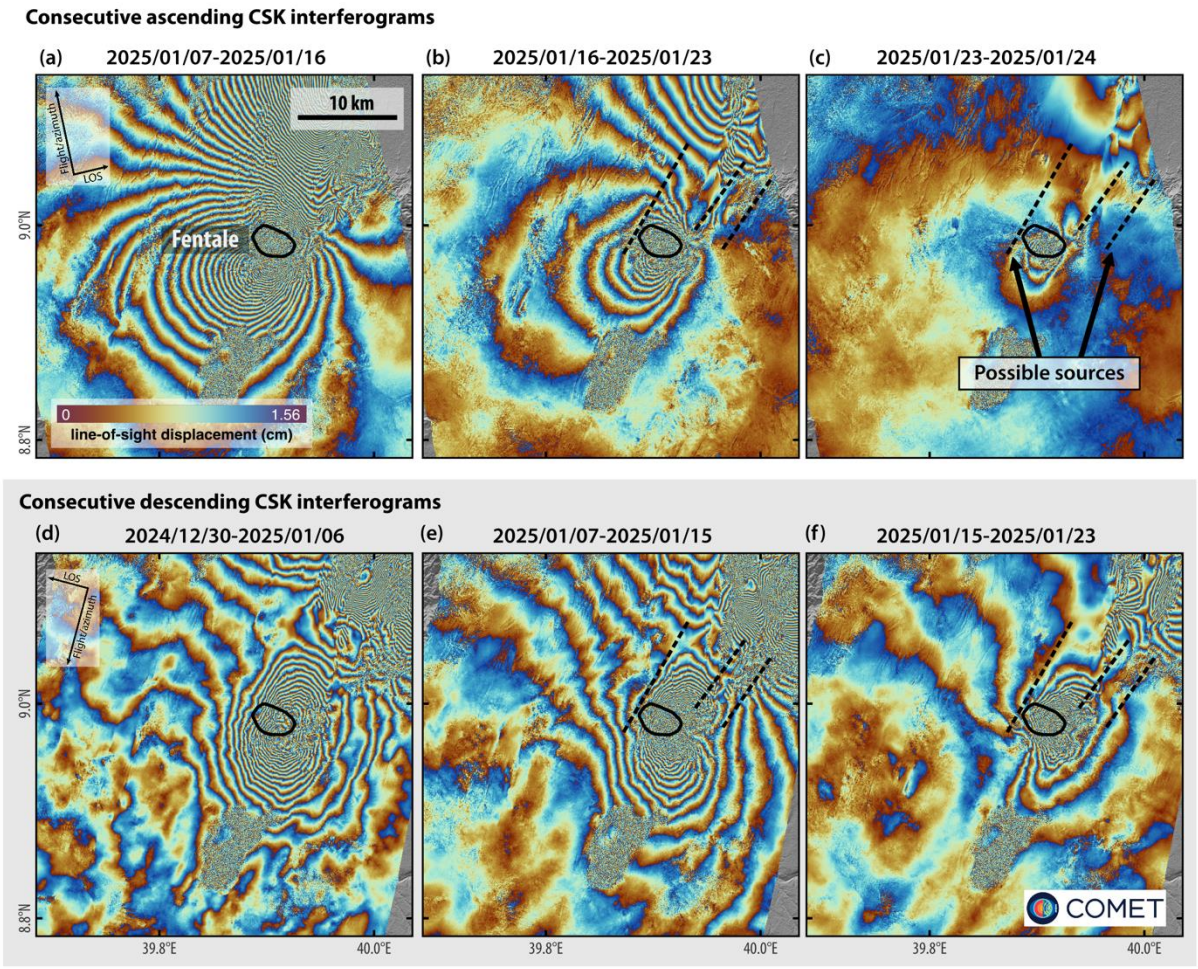

Fig 3. Change in deformation pattern at Fentale from the end of December 2024 to 24 January 2025, shown by consecutive COSMO-SkyMed (CSK) ascending and descending interferograms centred on Fentale. Possible sources contributing to the deformation pattern change in the 16-23 Jan (b: ascending) and 15-23 Jan (f: descending) images are indicated by the dashed black lines with NE strike. The crater of Fentale is drawn in a black solid line.

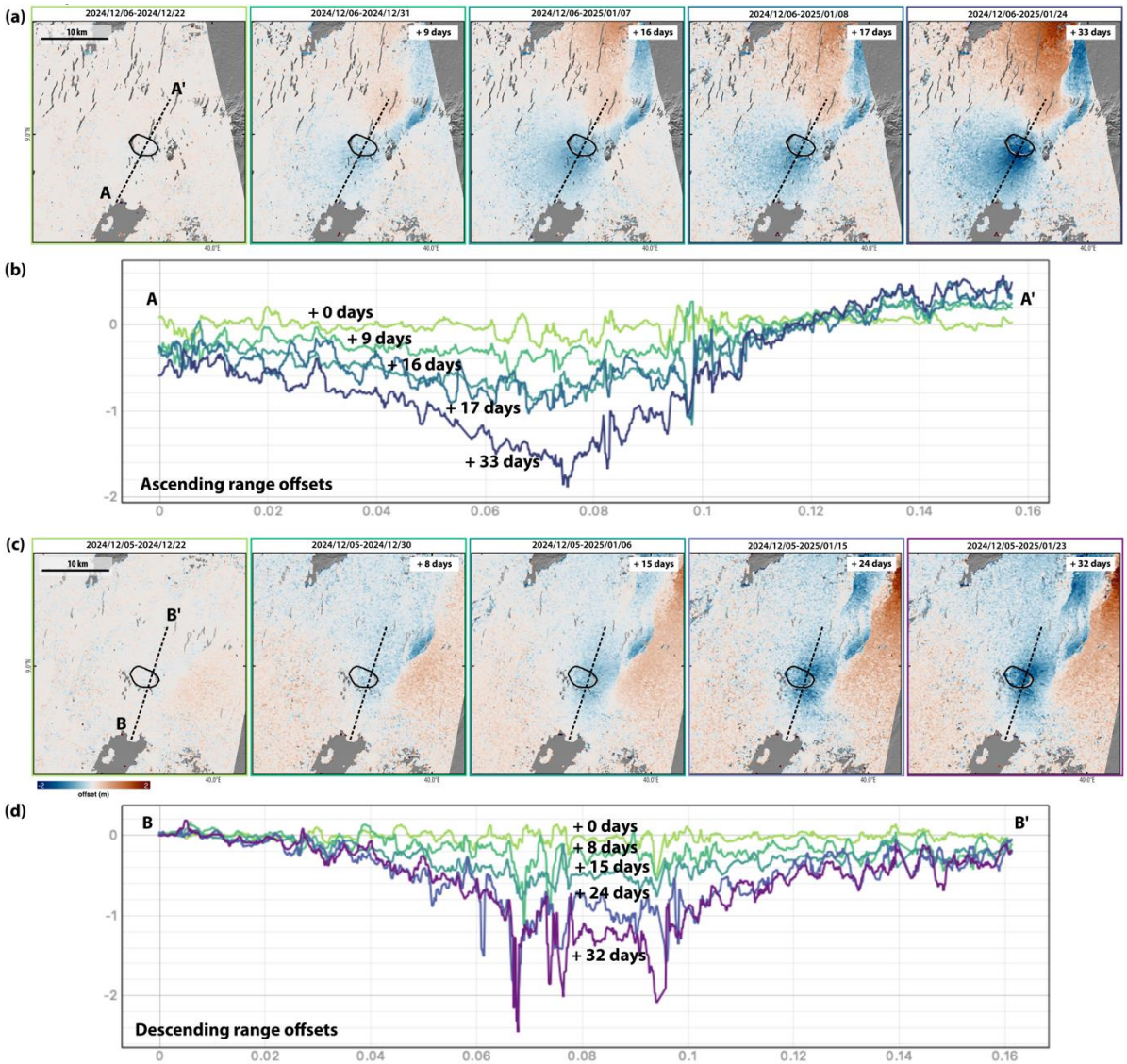

Fig 4. (a) Ascending and (c) descending cumulative CSK range offsets. Offsets are calculated with the same reference/starting date before the unrest started. (b,d) Profiles of range offsets across A-A' and B-B' do not show significant contributions from possible caldera ring faults along the longer axis of the caldera.

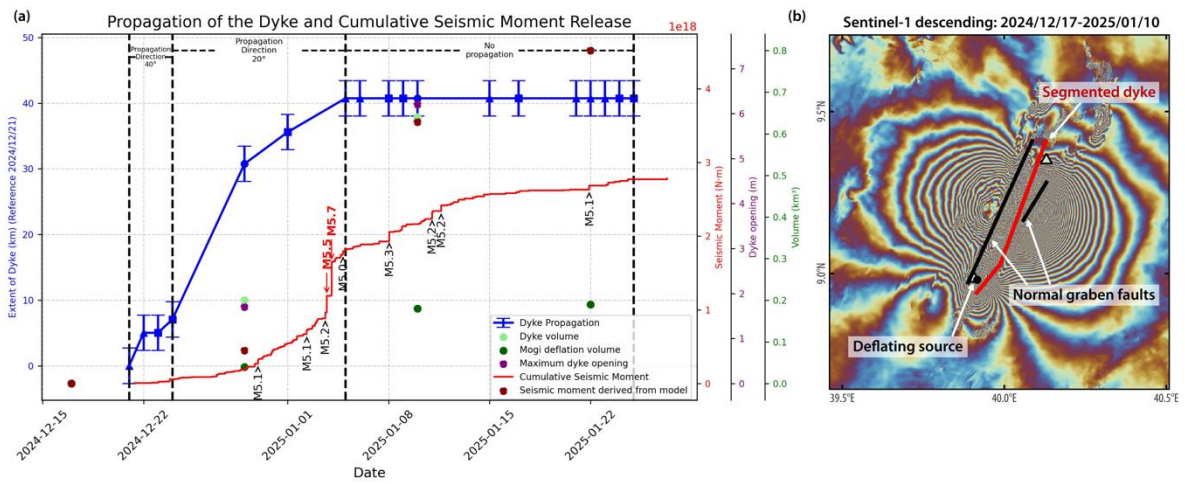

Fig 5. (a) Extent of dyke (blue line) and cumulative seismic moment release (red line) over time (updated from Event Report 1.4), including preliminary dyke and fault model estimates (markers) of the cumulative deformation since the start of the December 2024 unrest. Green markers represent the dyke volume (light green) and mogi deflation volume (dark green). The maximum dyke opening is indicated by purple markers, and the seismic moment derived from the model are in dark red. (b) Locations of the dyke, faults and deflating mogi source plotted on one of the Sentinel-1 interferograms used in modelling.