SnT 2025 8 SEPTEMBER ONLINE DAY 9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

P2.2-624

Colossal seismic activity of the Fentale-Dofen magmatic segment in the main Ethiopian rift from September 2024 to March, 2025: potential source for ground truth events

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INTRODUCTION AND MAIN RESULTS

The Fentale-Dofen volcanic segment is located at the transition between norther Main Ethiopian Rift (MER) and southern Afar which showed active deformation in recent years (Asfaw, 1981, Temtime et al., 2019 and Ayele et al., 2024).

Another intensive activity started in September 2024 and continued till March 2025 where events of magnitude 4.4 to 4.8 occurred with high frequency and were felt in nearby cities and towns including Addis Ababa. This seismicity is caused by dike intrusion which happens occasionally. The two major lessons learnt were the fact that the Ethiopian public managed to learn that Ethiopia is earthquake prone and the experience of Disaster Risk Management in Ethiopia is in an inception stage.

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Introduction

Rift morphology is dictated by repeated extrusive and intrusive magmatism through diking and faulting which spans over geological time scales.

The Fentale-Dofen magmatic segment, located at the northern end of the Main Ethiopian Rift (MER) (Figs. 1a&b), was demonstrated to be more active than the other volcanic centers in the northern MER by the 2001–2003 Ethiopian Afar Geoscientific Lithospheric Experiment (EAGLE) temporary seismic network (Keir et al., 2006).

The geophysical features happening in the Fentale neighborhood is becoming interesting in two aspects. The area being the transition between MER to the Afar Depression, it is attracting earth scientists for basic science research. On the other hand it hosts the railway and road access to the Djibouti port which is the lifeline of 120 million people in Ethiopia.

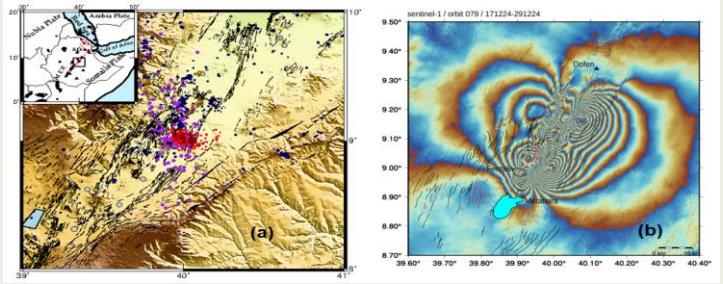

Figure 1. Map showing the location of the 2015 earthquake activity (in red dots) and purple color for part of the 2024/25 activity in Fig.1 (a) and InSAR deformation for limited time window Fig.1 (b)

Methods/Data

- Seismic records from limited number of broadband stations at local distance are acquired for the 2024-25 Fentale-Dofen magmatic activity. The seismic data at teleseismic distance is also used to characterize this unique episode
- Interferometric Synthetic Aperture Radar (InSAR) analysis (Fig.1b) from collaborating institutes in Europe together with seismic data helped us to constrain the activities location and hence inform the stake holders involved in Disaster Risk Management (DRM).
- On top of lacking enough seismic station in our region, we do not have a reasonable crustal model for earthquake location. We envisage that earthquakes sourced from well constrained active volcanoes in in Ethiopia and other regions in Africa can be used to generate at least a reasonable 1-D ***Regional Seismic Travel Time (RSTT)*** curve using the CTBO expertise & resources.

Major challenges

We still lack real-time data from densified seismic network and we haven't yet implemented machine learning techniques to automate data analysis practices. We used manual phase picking and analysis from limited number of stations.

Results

Intensive seismic activity sustained for about 7 months in the studied area. The earthquake swarm is caused by dike intrusion modelled from the InSAR data. A short-lived phreatic eruption reported around Dofen volcano. Over 80,000 people, mostly nomads, were displaced from their village. A sugar factory was heavily damaged and roads cracked but no causality reported

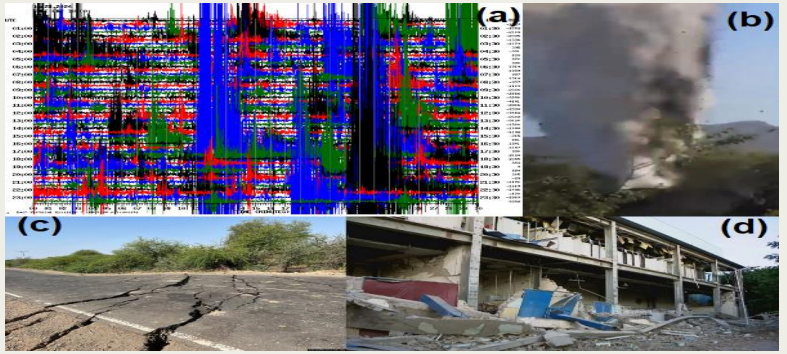

Figure 2.(a) helicorder data for a day, (b) reported phreatic eruption, (c) road cracks and (d) heavy damage on Kesem Sugar factory.

Conclusions

The seismicity analysis from local stations is still in progress. DRM practice in Ethiopia is still in inception stage which will cost life and property unless appropriate measure is taken on time.