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Terrestrial Magmatic Systems

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Imaging active magmatic systems at Oldoinyo Lengai volcano (Tanzania) via earthquake distribution (and attenuation mapping)

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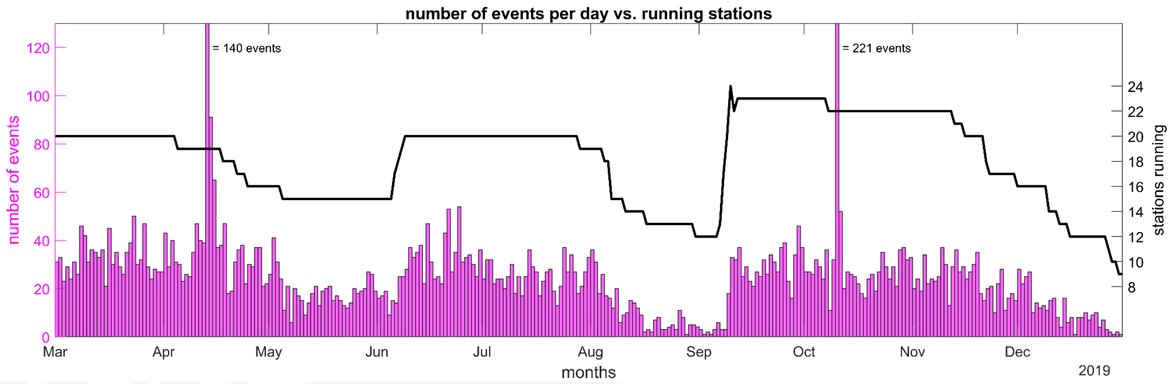
Motivation: Characterize the current seismicity of Oldoinyo Lengai and Gelai volcano and image the plumbing system

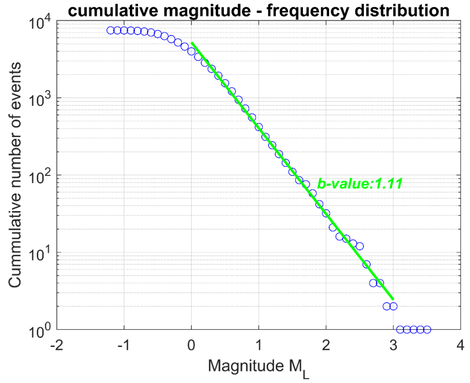
Oldoinyo Lengai is the Earth's only active natrocarbonatite volcano. It is located in the North Tanzanian Divergence and is part of a young rift segment (~3 Ma) in the East African Rift system.

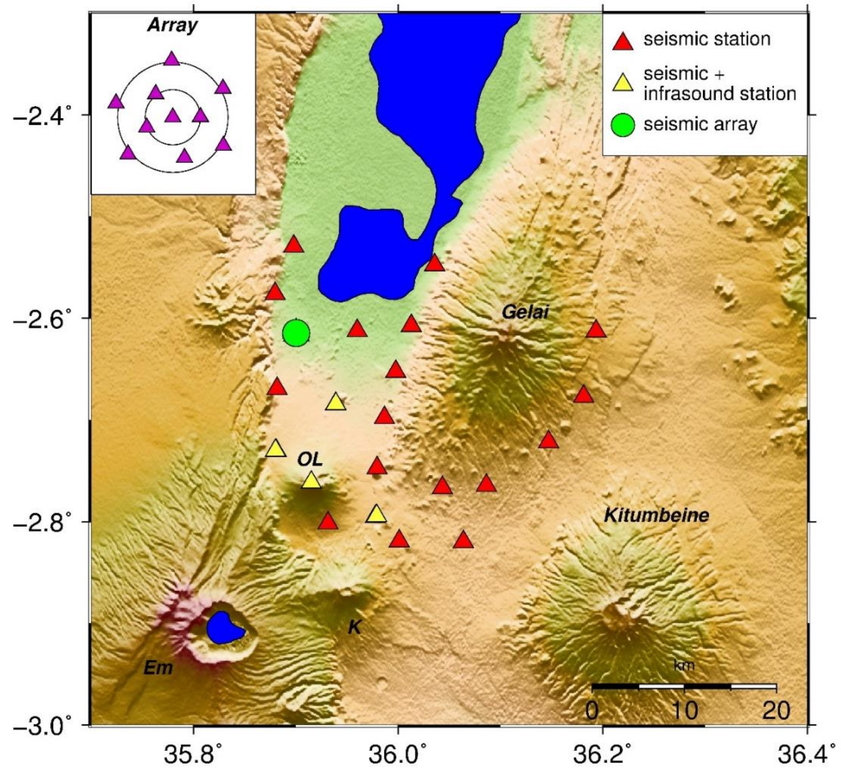
The volcano experiences long periods of effusive eruptions which are interrupted by short-duration explosions.

During the 2007-2008 rifting episode, an explosive eruption at Oldoinyo Lengai was preceded by an earthquake swarm at the inactive neighboring shield volcano Gelai.

Using data from the **SEISVOL** project, which encompasses both volcanoes, we show the seismicity obtained using QuakeMigrate and NonLinLoc for the first ten months. We locate 7210 earthquakes using a 3D velocity model of the region (Roecker et al. 2017). Per day, we locate 24 events on average with a b-value of 1.1 (see below; note the dependence of running stations on the number of detected events and the two seismic swarms in April & October).

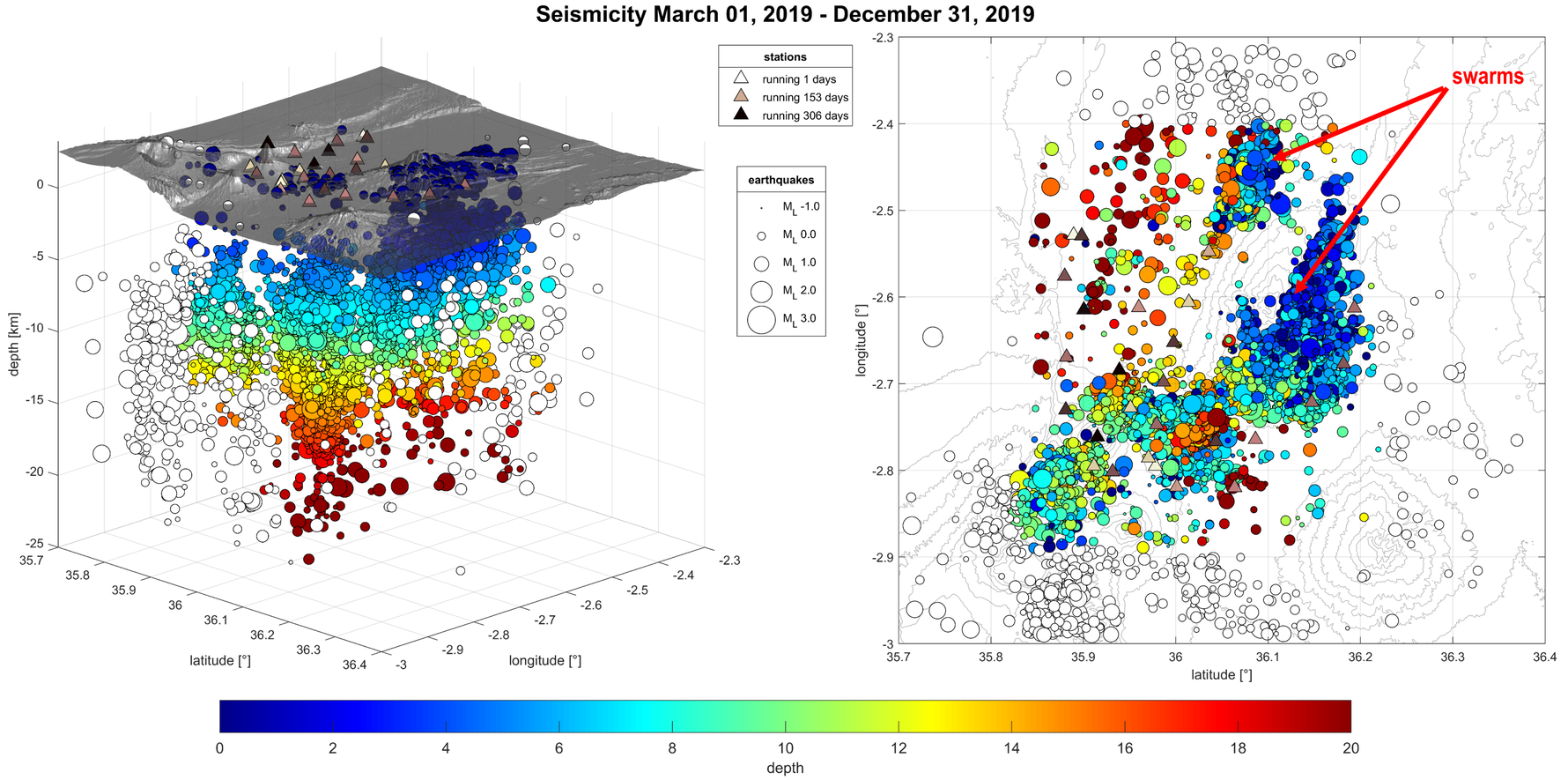




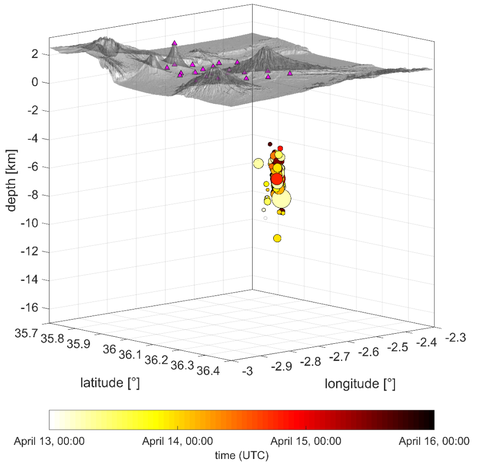


Station distribution of the **SEISVOL** project (Seismic and Infrasound Networks to study the volcano Oldoinyo Lengai, Reiss et al. 2019). This project is funded by the DFG (German Research Council). Fieldwork started in February 2019 and is set to last ~1.5 years.

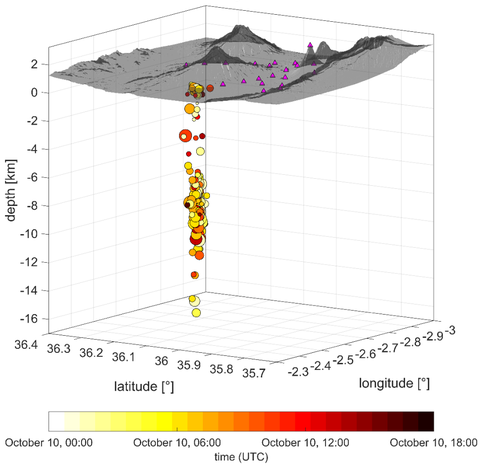
The current seismicity of Oldoinyo Lengai and Gelai volcano



Locations of manually repicked 1st swarm, ~260 events in three days



Locations of automatically picked 2nd swarm, ~210 events in one day



- Deep seismicity is located between both volcanoes beneath a monogenetic cone field (-> on top of a previously imaged magma chamber at ~20 km depth, Roecker et al. 2017).
- Gelai shield volcano shows strong, shallow seismicity including two seismic swarms (-> previous swarms in this area where interpreted to be due to a dike intrusion and degassing magma bodies).
- Events close to Oldoinyo Lengai cluster either northeast or southwest of the volcano.

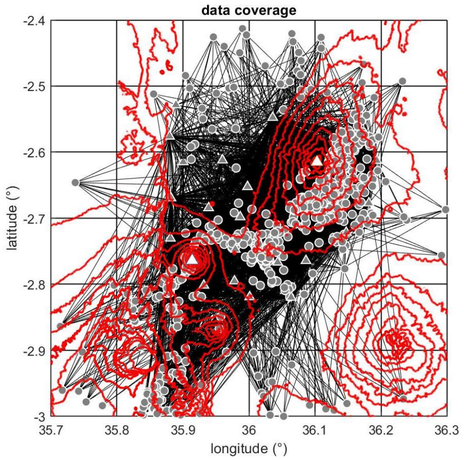
Attenuation mapping:

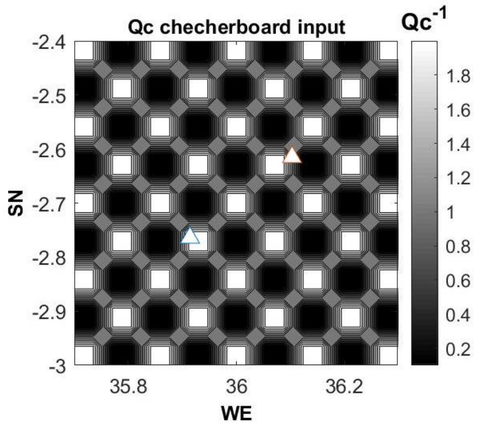
We use MuRAT – Multi-Resolution Seismic Attenuation Tomography (De Siena et al. 2014) to map absorption structures (Qc in a diffusive approximation) beneath Oldoinyo Lengai and adjacent volcanoes. We use all earthquakes located between March and July 2019 with M_L > 0.5 and only traces for which both P & S picks are available.

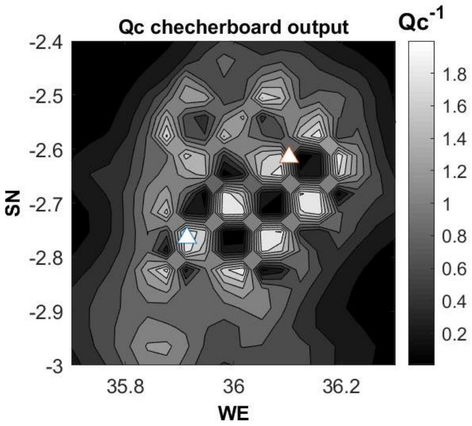
We image a high-absorption anomaly close to the dike intrusion of 2007 at Gelai shield volcano (green lines from Calais et al. 2008). The anomaly is retrieved at all frequencies which illuminate structures between 10 km depth and the surface.

Low-absorption anomalies likely mark colder, previously-intruded materials: (1) under the western and northern flanks of the Gelai shield volcano; (2) under the inactive Kerimasi volcano; and, (3) beneath/close to the eastern side of Oldoinyo.

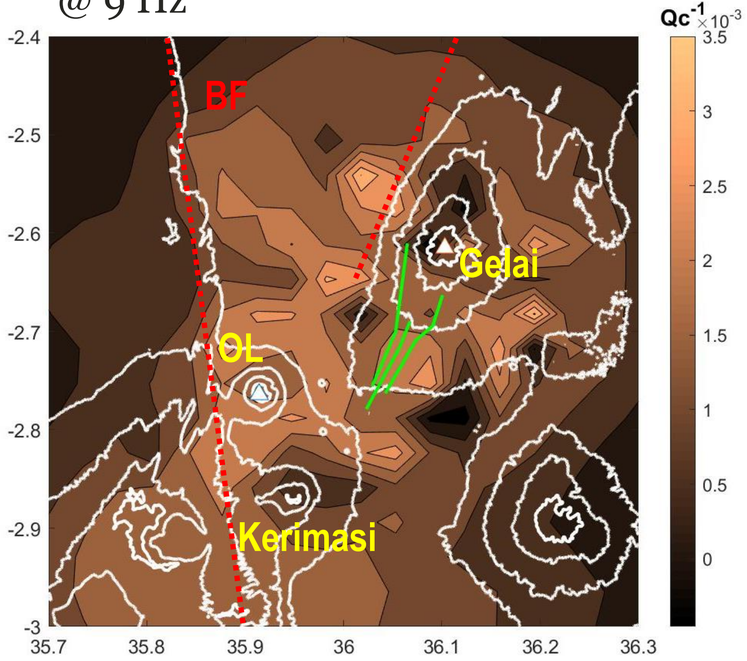
The high attenuation structures mark diffuse degassing across the entire rift region, particularly along the fault reaching the western foot of Gelai and the western border fault.



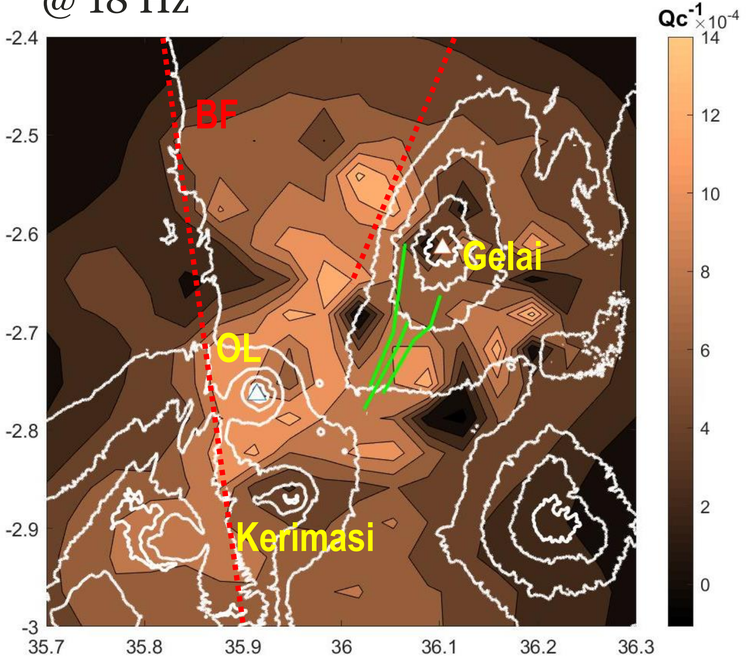




@ 9 Hz



@ 18 Hz



Summary & Outlook

Summary:

- Using data from the **SEISVOL** experiment, we observe ~7200 earthquakes in 10 months in 2019
  - Events are mostly confined to the volcanic centers with the strongest seismicity occurring beneath the inactive Gelai shield volcano
  - We observe two seismic swarms beneath the north-eastern and western flanks of Gelai (gas release, continuation of dike intrusion?)
  - Previous work as well as the observed pattern of seismicity suggest a connection between both volcanoes sourced from a central magma chamber
- We use MuRAT to image the attenuation structure beneath Oldoinyo Lengai and surrounding areas and find that low attenuation structures might relate to older intruded material, while high attenuation structures might be related to degassing.

Future work:

- Analysis of tremor events
- Pick focal mechanisms
- Refine automatic locations
- Do a time-dependent attenuation (scattering and absorption) analysis

Outlook:

The crater of Oldoinyo Lengai changed significantly in 2019. Using data from the crater stations, observed tremors might provide insight into shallow dynamics: