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

Assessment of local Seismic records and the largest earthquake magnitude in Comoro-Islands between 2017 and 2021

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INTRODUCTION AND MAIN RESULTS

This study uses a 5-year (2017, 2018, 2019, 2020, 2021, Magnitude (Md) ~ 0 to 4.95) dataset recorded by the Comoros Karthala Volcano Observatory (KVO). This period covers the 2018 earthquakes Mayotte swarm in the east. White et al. (2019) Submarine volcanoes at the Kermadec Arc, calculated b-values ranged “0.9-1.3”. The b-value calculated ($\mathbf{0.994}$ ± 0.13) matches the Mayotte submarine eruption.

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I- Introduction

The Comoros Archipelago is considered to be among the world's volcanic hotspots within the East African Rift System (EARS), represented as “hot spots” (red dots) World map (Davison, CR, & Rutke, T. "Assessment and Characterization of Volcanic Ash Threat to Gas Turbine Engine Performance."), situated in the Gde-Comore-Island.

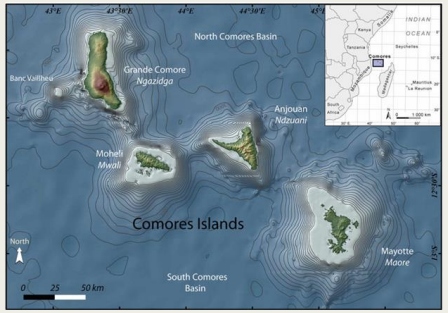

Fig.1: The Comoros Archipelago Bachelery et al., (2016)

Bachelery et al., (2016) represents this map in his study on the Structure and eruptive history of Karthala Volcano. He also reported: “The Comoros archipelago. (Bathymetry from GEBCO (General Bathymetric Chart of the Oceans) - http://www.gebco.net/, topography from SRTM (Shuttle Radar Topography Mission) http://www2.jpl.nasa.gov/srtm/. Isobaths every 200 m”

In 2018, a new type of active offshore volcano was discovered in the East of Mayotte Island [Feuillet et al., 2019a, 2021], following the seismic swarm that started in May 2018. Based on previously published studies, the reservoir of magma that caused the huge earthquake swarm with the highest record of seismic activity generated a Mw 5.9 on 15 May (Bertil et al., 2021) during the sequence of May 2018 in the east of Mayotte Island. The dedicated study period (2017-2021) has a profound meaning in deciphering the driven local volcanic and tectonic seismicity and the contrast that emerged in the data records between the two types of volcanic unrest from Karthala in Gde-Comore and the recent “Fani Maore” submarine volcanic activity. Spatiotemporal study of the period as well as the b-value and associated parameters are conducted using the Karthala Volcano Observatory (KVO) dataset (bulletin:2017-2021).

II- Data and Methods

II-1: Data: Data from the Karthala Volcano Observatory (KVO) seismic bulletin of events between 2017 and 2021 is collected from the original dataset, only events with calculated Md Magnitude (0-4.95) are kept. Those with available calculated duration magnitude (Md) are selected to keep the collection free of parameter gaps. The Comoros Karthala Volcano Observatory habitually determines duration magnitudes using Seiscomp3 (Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences and gempa GmbH, 2008). Dates & origin times, duration magnitudes, hypocenter locations, and depths are collected.

Table1: (5) events from each year are shown as an example of the type of bulletin (the highest Md of each year is represented), taken from the original dataset. The initial numbers from every single year are: 2017 (8), 2018(104), 2019(34), 2020(47), 2021(54).

Numb	Year	Magnitude (Md)	Longitude	Latitude	Depth (km)
1	20171210	3.337589569	42.16496658	-11.97770405	0
2	20180627	4.950292236	45.46710587	-13.08298397	18.11122513
3	20190521	4.736615239	41.52510834	-14.36745453	7.296042919
4	20200321	4.669080526	44.72452164	-12.35250473	0
5	20210820	4.820236378	41.82348633	-15.0362339	5.120010376

II-2: Analytic Methods: Five-year bulletin (Md≤4.95) are analyzed as spatiotemporal distribution where all zero (0 Md) are removed the spatial distribution as well as for the temporal distribution. Considering the binning process, only 10 events of the 104 events from the retained 2018 year were kept as the binning (4.0-4.1) is considered for the b-Value and associated mathematical parameters recalculated..

And Mw 5.9 event on 15 May during the May 2018 sequence (Bertil et al., 2021), east of Mayotte is used as reference of the 2018 Mayotte swarm highest calculated magnitude.

III- Results and Discussion

III-1: Spatial distribution of 5 years

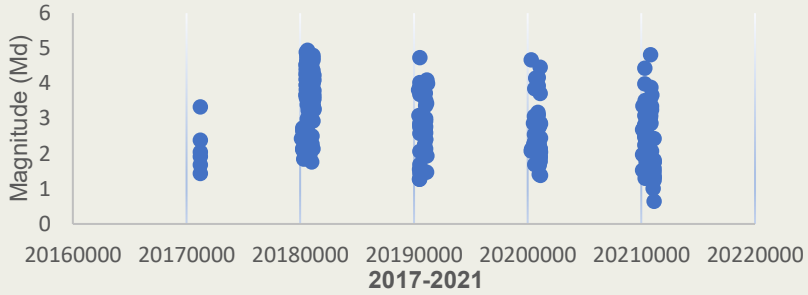

Fig:2: Spatial distribution of the 5years (2017,2018,2019,2020 and 2021) Md Magnitudes

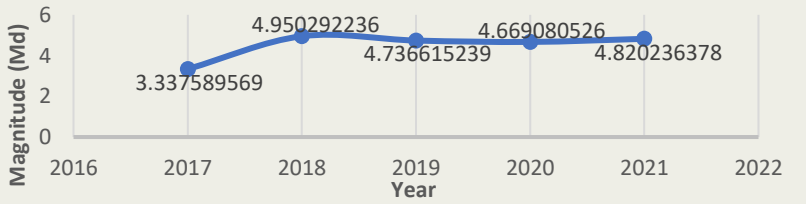

Fig.3: Highest (Md) magnitudes from each year

Fig.2 displays the spatial distribution of all 5 years data selected for this study. The distribution is made depending on the available bulletin, where, only original completed hypocenters (origin times, duration magnitudes, locations, and depths) are collected.

Fig.3 shows the evolution of the 5 highest (Md) magnitudes, each year.

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III-2: Temporal Analyses: b-value calculations

The Gutenberg-Richter law, Gutenberg, B., & Richter, C. F. (1944), proposed the empirical power-law used to evaluate seismic b-value estimation. The b-value calculation is conducted for year 2018, the most active among the 5, and in May the highest Magnitude (Md) is calculated in the (KVO). And the highest magnitude of the swarm period recorded the East of Mayotte Island is Mw5.9.

$$b = \frac{\log_{10}(e)}{\langle M \rangle - \left(M_c - \frac{\Delta M}{2}\right)}$$

The Mean magnitude ⟨M⟩ is expressed as:

$$\langle M \rangle = \frac{1}{N}\sum_{i=}^{N} M_i$$

Where N (number of events ≥ M_c), and $\mathbf{M_i}$ = magnitude of the *i-th* event

The table contains **N=62** (result from filtered dataset). The G-R Law avoids duplication of numbers that would bias the sensitive calculation of b-value; two numbers have been duplicated (Md 4.553 and Md 4.682), then removed to retain one from each identical.

- ***Sum of 62 magnitudes***:

$\sum \mathbf{M_i}$= 4.260+4.118+4.372+…+4.682 = 282.223

$\sum \mathbf{M_i}$ = 282.223 – (4.553+4.682) = **272.011** (duplication removed)

- ***Mean of magnitudes***: $\langle M \rangle = \frac{272{,}011}{62} = \mathbf{4.387}$

$$(\log_{10}(e) = \frac{\ln(e)}{\ln(10)} = \frac{1}{\ln(10)} \approx \frac{1}{2.302585092994046}$$

$$\log_{10}(e) \approx \mathbf{0.434294})$$

- ***Bias reduction***:

$(\Delta M/2)$ prevents overestimation of *b* due to binning artifacts, while *b* reflects the true earthquake size distribution. The bin explanation is made as (**4.0-4.1**), so, ($\Delta M/2$ = 0.1/2 = **0.05**).

- ***However, the b-value calculated is***:

$$b = \frac{\log_{10}(e)}{4.387 - (4.0 - 0.05)} = \frac{0.4343}{0.437} = \mathbf{0.994}$$

- ***Uncertainties*** are estimated by the standard deviation of the b-value (σ_b), for Aki's maximum likelihood method, it is calculated as: $\boldsymbol{\sigma_b} = \frac{b}{\sqrt{N}} = \sigma_b = \frac{0.994}{\sqrt{62}} = 0.126 \approx \mathbf{0.13}$

The ***Final b-value***: **0.994** ± 0.13 ≈ **1.0 ±0.13**

- ***Binning***:

The event before 4.0 is (3.9: several of them taken out among the 42 removed from the 104 event of year 2018, as they are considered to affect the b-value range for volcanic settings). 3.9 is rounded to 4.0 as the Mc value in this example. Then, **Mc = 4.0**

- ***Method: MAXC*** (Maximum Curvature) Woessner & Wiemer (2005): It is used after data binning (ΔM = 0.1) to compute cumulative counts (≥M).

Table 2: Cumulative Frequency-Magnitude Distribution (FMD).

M (Lower Bound)	$\log_{10}(N \geq M)$	Actual N ≥ M
4	1.792	62
4.1	1.771	59
4.2	1.732	54
4.3	1.708	51
4.4	1.681	48
4.5	1.623	42
4.6	1.568	37
4.7	1.505	32
4.8	1.447	28
4.9	1.342	22

IV- Conclusions

- 2018: The most active year (Mayotte swarm dominates catalog) KVO dataset. White et al. (2019) Submarine volcanoes at the Kermadec Arc, calculated b-values ranged "0.9-1.3".
- The B-value calculated (**0.994**) matches the Mayotte submarine eruption with a standard deviation ranging 0.994 ± 0.13 ≈ 1.0 ±0.13 fitting the author's one and in other previous studies.
- The results of this study show the importance of Harmonizing data sharing between Karthala Volcano Observation and Mayotte Volcano Observation for the performance of Volcano Monitoring within the Comoros Archipelago.