



Conference on Volcanic Processes: a Variety of Length and Time Scales | (SMR 4097)

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The Western Cameroon region, particularly the Cameroon Volcanic Line (CVL), has garnered significant research interest due to its complex geological features and dynamic geodynamic processes. Recognizing the significance of its tectonic and magmatic features associated with seismic and volcanic activity, this study focuses on geodynamic investigations of the Cameroon.

Focal Mechanisms and Depth control for the Recent Seismic Activity in the Fentale Region, Ethiopia: inferred from moment tensor inversion

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Abstract

The Fentale region, located in the northern Main Ethiopian Rift (MER), has recently experienced significant seismic activity, providing an opportunity to investigate the seismotectonic processes in this active rift segment. In this study, we analyze the focal mechanisms of earthquakes with magnitudes ≥ 4.5 that occurred between September 2024 and March 2025, using data from the Ethiopian Seismic Stations Network. Focal mechanism solutions were computed for 20 well-recorded events with high signal-to-noise ratios using the ISOLA software.

The derived focal mechanisms reveal a complex pattern of faulting, with both normal and strike-slip faulting regimes observed. The variability in fault orientations and slip directions highlights the influence of pre-existing structures and the interplay between regional extension and local stress fields related with the dike intrusion. These findings are consistent with the extensional tectonics of the Main Ethiopian Rift and provide insights into the active deformation processes in the Fentale region.

This study contributes to a better understanding of the seismotectonic framework of the Main Ethiopian Rift and underscores the importance of continuous seismic monitoring and advanced focal mechanism analysis for assessing seismic hazard in this tectonically active region.

Investigating Volcano Activity Using Infrasound and Seismic Data: A Case Study of the Tungurahua Volcano

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The Tungurahua volcano is one of the active volcanoes in Ecuador. It has erupted from 1999 to 2016, yet remains active. During that period, IGEPN (Instituto Geofísico Escuela Politécnica Nacional), Ecuador's geophysical institution, recorded Tungurahua's explosive activity. The data collection of Tungurahua from IGEPN included acoustic (infrasound) and seismic data. Researchers in vulcanology use the Volcano Acoustic-Seismic Ratio (VASR) method to study the behaviour and characteristics of volcanoes [1]. This study analyses the explosive activity of Tungurahua from 2006-2013 using the VASR. Based on Tungurahua's high explosive activity and inactivity, the explosive period is divided into 17 episodes. The results show two episodes with identical VASR trends. Episode 9 lasted from 26 May - 28 July 2010, and Episode 13 lasted from 14 December 2012 to 21 January 2013. Both early-stage episodes have a cluster of low VASR (0.1-10). The low VASR cluster was detected in the first 24 days and the first 7 days, respectively. Then, the VASR increased to a high level (VASR >10). The change from low VASR to high VASR variation of Tungurahua is believed to be associated with the clearing process from the choked conduit system to the open conduit system of Tungurahua through the explosions.

Keywords: Tungurahua volcano, infrasound data, seismic data, volcano acoustic-seismic ratio

[1] Johnson, J. B., Aster, R. C., *Journal of Volcanology and Geothermal Research*, 148(3–4), 334–354 (2005).

P03 Abstract: Numerical simulation of slope stability and landslides under different loadings in the Karongi district, western Rwanda

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The East African Rift (EAR) provides a unique setting to study interactions between geological processes, ecosystems, and societies. Like other tropical parts of the world, in western Rwanda, within the western branch of the Rift, steep slopes, high rainfall, and seismicity combine to contribute the area most vulnerable to slope failures and landslides. The central part of western Rwanda, Karongi district is the region most affected by landslides. Several investigations have been carried out recently to map landslide susceptibility in Rwanda, using various methodologies. On the other hand, there has been a lack of physical-based slope stability model resulting in inaccurate landslide forecasting, especially under different forcing factors.

This study explores slope instability and landslides in the Karongi District through the integration of numerical modeling. High-resolution Digital Elevation Model (DEM) was used in QGIS and simulate slope stability in Scoops3D software using the Limit Equilibrium Method (LEM) namely Bishop's Simplified Method for calculating Factor of Safety (FOS) under a range of conditions in soil characteristics, pore water pressure ratio, and seismic loading which in this case was represented by a Peak Ground Acceleration (PGA) of 0.065g, linking regional tectonic dynamics with localized risk. Historical landslide data between 2000-2019 allowed the validation of the predictive model. The modeled unstable zone having low FOS values ($FOS < 1.0$) align well with historical landslide locations in the North-West part of the study area and the other few regions of the Eastern part, hence showing the reliability of the model for identifying high-risk zones. The findings of this study also highlighted a horseshoe-shaped zone in the southeastern part of Karongi district that had shown low FOS values, with no recorded historical landslides. By geophysical modeling of slope stability and landslides, the research shows how interdisciplinary activities can make hazard mapping more effective and inform risk reduction activities.

How many crater lakes are in the Virunga Volcanic Province !

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Abstract

Research on volcanoes of the Virunga Volcanic Province within the western branch of East Africa Rift started hundreds of years ago, focusing on how active the magma chambers and surface features are. Studies have mainly looked at the emitted melt products, including solids and fluids of active volcanoes, neglecting dead parts such as crater lakes. Since the case of Lake Nyos (Cameroon) in 1986, IAVCEI has created the Volcanic Lakes Department. In places where volcanoes are active, large amounts of CO₂ are released from deep within the earth. This CO₂ can be stored at the bottom of volcanic lakes [1]. Crater lakes can be active or extinct depending on whether they are connected to their magma chamber. In terms of crater lakes, they contain small or large quantities of fresh magmatic fluids, including CO₂, H₂S, S, N, He, Ar, Kr and Xe. However, there are no exact records of crater lakes in Virunga. This paper reports about where are the crater lakes in Virunga and they can be a volcano monitoring tool. Field visits and remote sensing were used to identify crater lakes among the Virunga cones, in preparation for a water geochemistry test and any other scientific approach. Virunga has lots of craters, but few hot crater lakes. Most of Virunga's crater lakes are inactive maars, formed by hot-spot volcanism. Bottoms of at least 17 craters are filled with special volcanic material (scoria) that doesn't let water through. The most famous crater lakes are Green Lake and Black Lake in the city of Goma and the Tchengera, a special caldera that collapsed into Lake Kivu onto the south of Nyiragongo, in the northwest, near the town of Kitchanga, there are Mukoto, Ndalagha, Lukulu, Mbalukira and Mbita associated with the Nyamulagira. Kirwa and Kabindi Lakes are on the northern Visoke while Ngezi is in the south. The twin lakes of Burera and Ruhundo, Mutanda and Mulehe are connected to Muhavura dormant craters while Nyarakigugu and Karago are linked to Karisimbi. There are also volcanic lakes on the Visoke and Muhavura (Kabiranjuma) summits. The processes of tectonics, geomorphology and volcanology that formed crater lakes make them important windows and storage of magmatic fluids [2]. By studying the craters of the Virunga volcanoes, we have found that most of them have at least one crater lake located in each of the neighboring countries. A detailed chemical and geochemical investigation into the water bodies is needed to spot any powerful lakes to support any eruption about to happen.

[1] R. Dmitri; T. Franco; M. Amador, R. S. Laura; C. Veronica. *Past, present and future of volcanic lake monitoring*, 2014

[2] B. Christenson, K. Nemeth, D. Rouwet, F. Tassi, J. Vandemeulebrouck, J. C. Varekamp,. *Volcanic Lakes*, 2015

The Democratic Republic of the Congo in her eastern part faces significant volcanic and seismic hazards that most often cause significant damage in this part of the country. Among these hazards, are the volcanoes of the Virunga chain in the western branch of the East African Rift which includes eight main volcanoes of which only two are currently active. These are Nyiragongo and Nyamulagira (Mavonga et al., 2010; Namogo et al., 2016a).

The region around Nyiragongo is threatened by various hazards. First, the Nyiragongo is known for his fluid lava flows capable of producing rapid flows that can reach 100 km/h [Tazieff, 1977]. These lavas claimed victims during the eruptions of the Nyiragongo volcano in 1977, in 2002 and in 2021. Secondly, eruptive fractures can reach Lake Kivu and produce phreatomagmatic-lacustrine eruptions.

As these hazards can affect the million people who live on the northern shore of Lake Kivu, mainly in the cities of Goma (DRC) and Gisenyi (Rwanda), the region is at very high natural risk. Thus, the study of deformation of his crater and his southern flank since the apparition of the vent in 2016 in the crater of the Nyiragongo volcano until before her eruption in 2021 is essential for an understanding of the processes involved. This present study will be limited to the processing distance and extensometric measurements. These data of the distances that we were able to collect at the top of the crater but also with the extensometric data collected in the southern fractures of the Nyiragongo volcano.

Seismic Precursors and Shifting Patterns: A Spatio-Temporal Analysis of Kanlaon Volcano's Unrest (2017–2025)

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Kanlaon Volcano, one of the most active stratovolcanoes in the Philippines, has exhibited a progressive escalation in seismic and eruptive activity from 2017 to 2025, marked by evolving patterns in earthquake types, depths, and spatial distribution. This study presents a detailed spatio-temporal analysis of Kanlaon's seismicity using 3D relocated earthquake data to better understand subsurface magmatic processes and their relationship to eruptive episodes.

Initial hypocenter data were obtained using SeisAn and subsequently refined through 3D relocation with the LOTOS software package, significantly improving the spatial resolution of seismic clusters. Deep long-period (DLP) events were first detected in September 2017, followed by long-period (LP) volcanic earthquakes in December 2017. A notable volcano-tectonic (VT) swarm occurred in June 2020 on the northwestern flank at depths of 6–10 km, suggesting magma intrusion at mid-crustal levels, and marked the onset of heightened seismic activity. LP events re-emerged following the June 3, 2024 eruption. A shallow VT swarm occurred in September 2024 on the eastern to northeastern flanks, preceding the December 9, 2024 eruption. Additional moderate eruptive episodes followed on February 6, April 8, and May 13, 2025. A significant VT swarm was recorded on May 11–13, 2025 on the northern to northwestern flanks immediately before the latest eruption.

The spatial migration of VT swarms, alternating emergence of LP events, and increasing eruption frequency suggest dynamic changes in magma storage, pressurization, and migration pathways. These results underscore the importance of precise earthquake relocation and temporal sequencing in assessing volcanic unrest and enhancing eruption forecasting at complex stratovolcanoes like Kanlaon.



CONFERENCE ON VOLCANIC PROCESSES: A VARIETY OF LENGTH AND TIME SCALES. 1-5 Sept 2025, KIGALI, RWANDA.

NDAYISHIMIYE Elie, University of Rwanda, College of Science and Technology, Physics Department.

Title:

UNDERSTANDING VOLCANIC SYSTEM DYNAMICS ACROSS SCALES: FROM SUBSTANCE PROCESSES TO ENVIRONMENTAL IMPACTS.

ABSTRACT

Volcanic systems operate across a remarkable range of spatial and temporal scales, from the rapid propagation of magma beneath the surface to the long-term environmental consequences of eruptions. In alignment of science context, my research will focus on how integrated modelling approaches-both theoretical and numerical-help to illuminate the dynamics of multiphase flows within magnetic systems and their interaction to observable surface phenomena such as seismic signals and ground deformation. I will particularly be interested in how short-term scale events like explosive emissions or seismic bursts relate to long-term processes such as the evolution of volcanic lakes and the dispersion of volcanic gases in the atmosphere. Additionally, the interactions between volcanic materials and surrounding environment, including the soil-water systems and broader climatic feedback, underscore the need to bridge geophysical modelling with environmental and health perspectives. This conference offers an essential platform to engage with interdisciplinary approaches that connect deep earth processes with surface hazards and long-term planetary change.

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Review of Plumes in a Rotating Two-Layer Stratified Fluid

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Abstract

This review examines experimental studies of (descending) plumes in a rotating two-layer stratified fluid. It investigates the influence of the Coriolis force on plume spreading and ultimate penetration through a density interface. Plumes that evolve over long times and very large domains must become affected by both the Coriolis force and stratification, such as giant volcanic eruptions. The objective is to: 1) study the dynamics of plumes in the presence of the background rotation and compare it with the non-rotating case and identify associated effects, including plume precession, cyclonic circulation, and anticyclonic lens; 2) analyze the behaviour of plumes at the density interface, such as spreading and penetration, and; 3) evaluate radial position of intrusion front, penetration time, and other parameters. This review synthesized findings from one paper that studied plumes in a rotating two-layer fluid, two other papers that studied plumes on a uniform-density rotating fluid, and a few papers that studied the non-rotating case. This indicates a gap in the literature regarding the study of plumes in rotating frames. In the literature, we find values of radial advance of the intrusion relatively higher in non-rotating experiments and relatively smaller in uniform-density rotating fluids. In our case of interest, a rotating two-layer field, we find these values higher in early times and smaller in later times due to Coriolis effects. Also, penetration time turns out to have a simple relation that depends on the angular frequency of the rotation and the buoyancy parameter. This relation differs from non-rotating experiments, such that it has a characteristic time-scale $1/(\text{angular frequency})$; other non-rotating experiments may use a time-scale that is a function of the cross-sectional area. This review underscores the need for a theoretical framework that could, from first principles, account for complications of plume dynamics and lens evolution under the influence of stratification and rotation.

Analysing the influence of Geological Structure and Alteration Zones on Gold Mineralisation within the Southern Kibi-Winneba Greenstone Volcanic Belt

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This study examines the spatial relationship between delineated subsurface lithological structures and alteration zones with gold mineralised zones within Ghana's southern Kibi-Winneba belt using geophysical and remote sensing datasets. This volcanic greenstone belt mostly comprises Birimian metavolcanic and volcano-sedimentary rocks, remains of ancient volcanic activity. Key lithological units and intrusive formations were identified by extensive magnetic, gravity, and radiometric data analysis. Structural lineaments derived from magnetic and Sentinel-2A imaging exhibited pronounced NE-SW and N-S orientations, aligning with regional tectono-magmatic influences on gold mineralisation. Alteration zones were delineated by Principal Component Analysis (Crosta approach), emphasising putative hydrothermal signatures of subsurface magmatic activity. This research culminated in the development of a mineral prospectivity map, classifying regions according to varying levels of gold potential. The validation of geochemical data and artisanal mining sites confirms the relevance of this synthesised approach in identifying the influence of historical volcanic and magmatic activity on the development of current mineral systems. Outputs from this study, improves understanding of the persistent influence of paleovolcanic systems on the distribution of earth resources and land use in tropical regions.

ABSTRACT FOR THE CONFERENCE ON VOLCANIC PROCESSES:

A VARIETY OF LENGTH AND TIME SCALE

TITLE: HARNESSING VOLCANIC PROCESSES FOR GEOTHERMAL ENERGY

AUTHOR: JOSEPH MWANGI

Insights from Temporal and Spatial Scales to Advance Renewable Energy Engineering.

This research explores the interplay between volcanic processes and geothermal energy systems, emphasizing the importance of understanding temporal and spatial scales in optimizing renewable energy extraction. By analyzing heat transfer dynamics, subsurface interactions, and volcanic activity, this study aims to enhance geothermal resource assessment and mitigate project risks. The findings highlight the potential of volcanic regions as sustainable energy sources, offering innovative solutions for clean energy.

Key Research Areas

- a) Heat transfer dynamics in volcanic systems**
- b) Subsurface interactions and Thermal mapping**
- c) Risk assessment and mitigation strategies**
- d) Sustainable energy extraction methods**
- e) Interdisciplinary engineering solutions**

Advancing Renewable Energy Engineering Through Volcanic Process Understanding

X

joseph mwangi
energy and reservoir engineer

Seismo-Acoustic Analysis of Ash Emissions Associated with Eruptions of Nevado del Ruiz Volcano Between 2018 and 2024.

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Between 2018 and 2022, Nevado del Ruiz Volcano (NRV) exhibited surface activity characterized by ash emissions and minor explosions. This study analyzes the acoustic and seismic signals associated with these events to gain a deeper understanding of the volcano's eruptive dynamics. Using data from six acoustic stations and broadband seismometers, relevant acoustic events were identified and correlated with seismic signals of the LP (long-period), EX (explosive), and volcanic tremor types.

The acoustic signals are linked to the release of pressurized gases from depth, where the volcanic system acts as a valve allowing depressurization. Signals were classified based on acoustic energy (Pa) and seismic energy (Dr), as well as dominant amplitudes and frequencies. This approach allowed the identification of patterns that reflect changes in the eruptive style of NRV.

The results demonstrate that seismo-acoustic analysis is a key tool for detecting variations in volcanic behavior, facilitating early identification of eruptive processes and improving our understanding of the volcano's surface evolution.

Nyiragongo eruption 2021 and its environmental impact: Effects of volcanic ash fallout on drinking water and edible vegetables

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Nyiragongo (DR. Congo) is an active intraplate volcano well known for its fascinating persistent and impressive lava lake inside the crater and is recognized as one of the most dangerous volcanoes in the world as more than two million people live on its slopes, 18-20 Km far from the main crater. It is located in the Virunga Volcanic Province (VVP), in the western branch of the East African Rift System (EARS), at the intersection between the DR. Congo, Rwanda, and Uganda. Unexpectedly, on 22 May 2021, Nyiragongo produced three different lateral lava flows in the low flanks and significant amounts of volcanic gas and ash were emitted from the summit crater following the collapse of the crater floor. For several weeks, the ash fallout strongly impacted the main cities of Goma and Gisenyi and the numerous villages located in the vicinity of the volcano in both DR. Congo and Rwanda countries. During and after the eruption, 22 samples of volcanic ash, 135 drinking waters, and 32 leaf samples of different edible plants were collected in rural villages at different distances from the volcano. The samples were analyzed for the major, minor and trace constituents, including all those elements recognized as potentially toxic (PTEs) to human health and the environment components in general. The preliminary results are particularly alarming as most of the drinking water sampled was found to be heavily contaminated with fluoride, chloride, sulphur, and many trace metals (As, Cd, Cr, Cu, Mo, Pb, Sb, Se, Te, Tl, and V), potentially toxic to human health. The plants analyzed were also found to be strongly contaminated by the extensive deposition of volcanic ash, and by the consequent release of water-soluble ash-borne species (mainly sulphates and chlorides). Most of the analyzed chemical elements exceeded the suggested

World Health Organization (WHO), the European Union (UE), and the Food and Agriculture Organization of the United Nations (FAO) for both drinking water and food plants limits during and few months after the eruptive period. The two processes that caused the heavy environmental contamination are mainly due to the interaction of rainwater with the volcanic plume and the leaching of the emitted ash. Further studies are still in progress to define the risk factors for the population exposed to the important event in the VVP.

Key words: Nyiragongo, Environmental impact, drinking water, plants, Virunga

Review of Insights into East African Tectonic Dynamics via InSAR and Seismic Deformation Monitoring

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ABSTRACT

The East African Rift System (EARS) is an active continental rift where deformation arises from both tectonic faulting and magmatic processes. The East African Rift System (EARS) is composed of around 78 Holocene volcanoes, but relatively little is known about their past and present activity. This lack of information makes it difficult to understand their eruptive cycles, their roles in continental rifting and the threat they pose to the population. This lack of information makes it difficult to understand their eruptive cycles, their roles in continental rifting and the threat they pose to the population. Although previous InSAR surveys (1990–2010) showed sign of unrest, the information about the dynamics of the magmatic systems remained limited by low temporal resolution and gaps in the data set. Using InSAR time series, GNSS, and seismic catalogs, recent work resolves millimeter- to centimeter-scale motions that map fault slip, dyke intrusions, and shallow magma-reservoir pressurization across Ethiopia, Kenya, Tanzania, and neighboring regions. A five-year Sentinel-1 survey showed deformation at ~20% of Holocene volcanoes, highlighting diverse behaviors—steady trends, pulses, and sigmoid—linked to magma transport and hydrothermal systems. In Afar, the 2005–2010 Dabbahu–Manda Hararo rifting episode featured a mega-dyke and a sequence of >10 intrusions, demonstrating that dyking can dominate extension and trigger cascading stress transfer along segmented rifts. Post-rifting viscoelastic relaxation and fault after slip further modulate deformation fields detected by InSAR. In the Kenyan and southern Main Ethiopian rifts, integrated InSAR–seismic analyses reveal low-amplitude, long-wavelength strain, shallow magma sources (2–5 km), and variable coupling between neighboring centers—all critical for hazard assessment and geothermal development. Region-wide geodetic strain models and reviews consolidate these observations, showing along-rift variability in magmatism, segmentation, and seismogenesis, and underscoring the need for routine, automated satellite monitoring tied to local seismic networks. Together, these studies illustrate that combining InSAR with seismicity provides a robust framework to separate aseismic magmatic deformation from brittle faulting, refine hazard models, and track the ongoing evolution of continental breakup in East Africa.

Plume Dynamics and Lava Flow; Modelling of Volcanic Hazards.

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Direct assessment of volcanic hazards remains a major challenge due to limited observational capabilities and the limitations of the modelling approaches. Yet, nearly 10% of the world's population lives under the threat of one, out of the approximately 1,500 active volcanoes worldwide. This stresses the need for more advanced and effective models to improve hazard quantification and support risk reduction. This literature review presents numerical models used to solve two distinct problems; monitoring the rise through the atmosphere of ash-laden volcanic plumes; and the interaction of volcanic lava flows with topography and obstacles, yielding crucial insights into lava flow on an inclined plane. In the attempt to address the two problems, several key questions have to be answered to be able to attain accurate quantifications of the hazards. One of the major objectives of this literature review is to provide insights into how the mass, momentum, and buoyancy flux of a volcanic plume can be determined in the presence or absence of wind and how to determine the volume flux per unit width for lava flows and obstacles.

Lateral Magma Propagation in Rift Zones: Insights from Diverse Tectonic Settings and the 2021 Nyiragongo Eruption

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This review explores how magma moves laterally through rift zones, drawing on examples from different tectonic settings and lessons from the 2021 Nyiragongo eruption. Because rift zones are often home to large populations, gaining a better understanding of magma transport is crucial for improving eruption forecasts and reducing volcanic risks. The main goals of this work are to: 1) outline the processes that enable dykes to propagate sideways, 2) examine evidence from seismic, geodetic, and field studies, and 3) discuss the broader implications for hazard monitoring. Findings from the literature show that magma pathways are controlled by a complex interaction between multiple factors. Because magma is less dense than the ambient rock, buoyancy is a critical force that always drives magma upwards. This upward movement interacts with other forces, including viscous stresses, source overpressure, and tectonic stresses. Some studies highlight the influence of pre-existing fractures and fault structures, while others stress the role of driving pressure conditions within the magma itself. The Nyiragongo eruption of 2021 clearly demonstrated how lateral magma flow can trigger sudden flank eruptions far from a volcano's summit, catching communities by surprise. These insights underline the importance of combining seismic and ground deformation monitoring with field observations to improve preparedness in active rift systems.

Caracterización de los depósitos de tephra asociados a la actividad eruptiva del Complejo volcánico Cerro Bravo (Colombia).

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The Cerro Bravo Volcanic Complex (CBVC), located in the Central cordillera of Colombia, is an active volcanic structure, in dormant state. Since the end of the Pleistocene to Holocene, its eruptive activity has been explosive of Plinian to sub-Plinian type and has been accompanied by the rise and destruction of domes. The geological record shows at least 22 eruptions, where the most explosive have reached VEI 4 - 5, which have generated deposits of both concentrated and diluted pyroclastic density currents, pyroclastic falls and lahars. The outcrops of the pyroclastic fall deposits associated with the CVCB show one of the most complete exposures of this type of deposits in Colombia. Isopach and isopleth maps allowed us to calculate parameters related to the eruptive dynamics of units CB1–CB9, showing that the preferential distribution direction was toward the southwest–west; and where an eruptive phase (eruption 4500 Y BP) with a maximum tephra volume of 1.2 km³ and a column height of 25 km. These deposits were classified as simple, simple-stratified and multiple plinian deposits.

These data served as input to carry out computer simulations, which were incorporated into the second version of the CVCB hazard map, shows that the area that can be affected by tephra includes important towns such as the cities of Manizales, Pereira, Armenia, Cali, Quibdó, Ibagué, Bogotá, among others.

SEISMIC EVENT ANALYSIS AND MAGNITUDE MEASUREMENTS ALONG THE RWIMI-WASA AND KISOMORO FAULTS, RWENZORI REGION

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The Rwenzori region, located within the western branch of the East African Rift System, is a tectonically active area characterized by frequent low-to-moderate magnitude seismic events [1]. This area is a significant geological feature, defined by the uplifted Rwenzori horst block and characterized by Precambrian metamorphic rocks and Cenozoic rift-related sedimentary deposits. This study presents a detailed analysis of seismicity and magnitude measurements along the Rwimi-Wasa and Kisomoro faults, with the objective of understanding fault activity and its implications for regional tectonics.

Using a network of four seismic stations in Uganda (Mbarara, Hoima, Kilembe, and Entebbe), we processed data from 198 earthquake events recorded between 2021 and 2022. We used the SEISAN software suite to locate event epicenters and calculate local magnitudes (ML), which ranged from 1.9 to 4.6. The spatial distribution of seismicity, visualized with PyGMT, reveals a strong concentration of events in two main zones, with the highest cluster located between the Kilembe and Hoima stations.

Our analysis shows that seismicity is strongly correlated with the surface traces of the NNE–SSW-striking Rwimi Fault (030°–040° azimuth) and the Kisomoro Fault (035°–045° azimuth), both dipping steeply to the southeast. These are identified as major normal faults accommodating the east-west extension of the rift system. The most frequent magnitudes were between 3.0 and 3.8, with no events exceeding ML 5.0, indicating moderate stress release within the brittle crust.

This work contributes to the understanding of active fault systems and their geological context in the Rwenzori region and provides a scientific basis for seismic hazard evaluation. The results highlight the need for continuous monitoring and further geophysical investigation to constrain fault behavior and inform disaster risk reduction strategies in this structurally complex and densely populated area of western Uganda.

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Abstract template for Conference on Volcanic Processes: a Variety of Length and Time Scales

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Magma-filled fractures propagating steeply through the brittle crust are known as dikes; understanding their propagation mechanism is critical to assessing volcanic risk because dikes feed most eruptions. Understanding the dynamics of magma propagation within volcanically active zones, such as Mount Nyiragongo and Lake Kivu, is crucial for evaluating volcanic risks and managing hazards in tectonically stressed environments, where various factors, including geological stress fields, upper crust rheology, and internal thermodynamic conditions such as magma temperature, pressure, and groundwater presence influence magma movement. This work focuses on magma dynamics during propagation under simulated stress conditions, emphasizing the geological and physical controls that govern flow paths and surface interactions. Six controlled analog experiments were conducted to address the significant gap in understanding how material properties, magma buoyancy, and external stresses influence magma flow, especially under lateral extension conditions. These experiments used gelatin as an analog material, varying the concentration, salt content, applied load, and amount of lateral extension applied to simulate different geological conditions.

Additionally, Tracker software was utilized to gather and analyze experimental data, providing comprehensive information on vertical and lateral transport, along with flow velocities over time. We also study the dike geometry at different time steps to study the effect of lateral extension on dike geometry. The findings suggest that material elasticity, external loads, and buoyancy-strongly influenced by salt concentration-significantly impact magma propagation. Increased buoyancy and decreased lateral extension gradients facilitate vertical magma propagation.

These insights improve volcanic risk assessment and provide a predictive framework for understanding lateral magma movement in tectonically stressed areas, offering practical knowledge to model magmatic activity in active volcanic settings.

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Transition from irregular to sustained lava lakes activity in continental rifting

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Abstract

Lava lake activity is a fascinating manifestation of subaerial volcanism, but the mechanisms involved in its evolution are still poorly deciphered. It is the case in the Virunga Volcanic Province (VVP), where the eruptive activity was intermittent in the years following the Nyiragongo lava lake draining event on May 22, 2021. Unprecedented monitoring of soil degassing was performed during this peculiar period to investigate the ability of this technic in deciphering complex magmatic and tectonic processes inherent to continental rifting. A main degassing anomaly was identified during the first semester of 2024, anticipating a renew of continuous eruptive activity in the VVP. The comparison with local seismic activity revealed a close relation between soil degassing and volcanic seismic signals able to be used to (i) track deep magma replenishment and transfers towards shallower levels, and (ii) provide insights about the evolution of the eruptive activity and of rifting processes.

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Historical Thermal Changes and Their Drivers in Lake Kivu: Toward Detecting Future Unexpected Stratification Changes

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The uniqueness and complexity of Lake Kivu's stratification arise from variations in density-related factors, including high concentrations of dissolved carbon dioxide (300 km³), methane (60 km³) and temperature, that increase with depth. Subaquatic inflows originating from geological systems associated with two active volcanoes, Nyamuragira and Nyiragongo, play a key role in maintaining the lake's permanent stratification and enabling the accumulation of dissolved gases in its deep waters. Lake Kivu's stratification has been known to be influenced by both climate change and volcanic activity in the region. In addition to exchanging heat with the atmosphere, the lake receives heat through deep water inputs from subterranean groundwater sources and geothermal heat flux. While previous studies have investigated temperature changes in Lake Kivu, particularly revealing that warming above the main gradient (250/260 m) is attributed to climate change, less attention has been given to the deeper layers. Past changes and their underlying drivers remain poorly understood. This ongoing work aims to explaining observed thermal changes and identify their key drivers. In parallel, the work introduces the concept and preliminary design of a future Early Warning System (EWS) intended to detect and alert for unusual stratification changes, whether caused by methane extraction or volcanic activity. The proposed EWS will enhance the existing lake model by integrating it with an observational monitoring database. This linkage will enable continuous comparison between observed data and model projections, allowing the system to flag unusual deviations. By proving such a tool, this project seeks to support riparian governments and relevant stakeholders in the sustainable management of Lake Kivu and its resources.

PETROGRAPHIC STUDY AND MAPPING OF THE VOLCANIC CONES OF THE VIRUNGA: CASE OF THE NORTHERN BELT OF LAKE KIVU

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This study aimed to determine the petrographic nature and the geographic distribution of volcanic cones in the northern belt of Lake Kivu. The study area is located in the peripheral zone of Lake Kivu, south of the equator, between 1°37' South latitude and 29°14' East longitude, within the active volcanic field of Nyiragongo and Nyamulagira, in the city of Goma. The methodological approach combined systematic field investigations and geospatial analysis. Seven volcanic cones were studied through direct observations, lithological descriptions, and sample collection. Rock samples were georeferenced-using GPS, later analyzed in the laboratory using a petrographic microscope, and specialized GIS software such as ArcGIS, Surfer, and QGIS. In parallel, remote sensing data, including LANDSAT and SENTINEL-2 satellite images, were processed to produce NDVI and land use maps, enhancing the spatial understanding of vegetation cover and human occupation in the area.

Volcanic dynamics of our sector reveal that cones located in the immediate vicinity of Lake Kivu-such as Mont Goma, Nzulo, CCLK (Nyabyunyu), Buhimba, Kinyogote, and Lac Vert-exhibit eruptive characteristics typical of phreatomagmatic activity, indicating interactions between magma and surface or groundwater. In contrast, cones located farther from the lake, such as the Ndosho cone, are associated with strombolian activity, characterized by fluid lava emissions accompanied by moderate explosive events. From a cartographic perspective, the spatial distribution of the volcanic cones follows preferential alignments oriented NE–SW. These alignments correspond to the main active faults in the area and reflect the dominant structural orientation of the East African Rift in its western branch [1]. Petrographic analysis revealed the exclusive presence of volcanic rocks in the region, including basalts, volcanic tuffs, lapilli, volcanic ash, pyroclastic breccias, and scoria. Basalts play a fundamental role in the local geology, as they constitute both the dominant surface formations and the underlying bedrock of the region.

The presence of recent phreatomagmatic centers along the northern shoreline of Lake Kivu combined with unplanned urbanization in densely populated areas such as Goma, Sake, and Gisenyi, significantly increases the vulnerability of local populations to volcanic hazards [2]. This situation highlights the urgent need for improved urban planning and the implementation of a comprehensive risk management strategy, incorporating both volcanic monitoring and land-use planning.

Keywords: Petrography, Mapping, Volcanic cones, Northern belt of Lake Kivu, Virunga

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Crystallization Conditions of the Villamaría-Termale Monogenetic Volcanic Field, in Manizales, Colombia.

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The Villamaría-Termale monogenetic Volcanic Field (CVMVT) refers to a cluster of volcanoes that are located in the west flank of the Central Cordillera of Colombia (Murcia et al., 2019). The field is composed of 19 volcanoes classified as lava domes and lava flows (Botero-Gómez et al., 2023). The dominant composition is andesitic to dacitic, occasionally varying to basaltic andesite, all of them with calc-alkaline affinity (Osorio et al., 2018). This work presents the mineralogical and geochemical characteristics of the Amazonas and Sancancio lava domes, as well as the Lusitania lava flow. The rocks exhibit andesitic composition and porphyritic texture with a glassy groundmass. Essential minerals are pyroxene (clinopyroxene augite and orthopyroxene enstatite), amphibole (magnesiohastingsite) and plagioclase (andesine and labradorite). Orthopyroxene, clinopyroxene, amphibole and plagioclase geothermobarometry indicate a temperature, pressure and depth range from 933 to 1209°C, 1.61 to 0.33 GPa, 61 to 2km; 915 to 1187°C, 0.92 to 0.16GPa, 35 to 6 km; and 917 to 1221°C, 1 to 0.16 GPa, 38 to 6km, to Lusitania, Amazonas and Sancancio occurrences, respectively. Amphibole provided oxygen fugacity values that indicate moderate to high oxidation conditions during crystallization. The results suggest that magmatic evolution involved processes such as fractional crystallization, crustal contamination and adiabatic decompression before the magma reached the surface.

Keywords: Central Cordillera of Colombia; Monogenetic volcano; Geochemical; Geothermobarometry.

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From Lava to Magnet: Deciphering Magnetic Memories in Volcanic Rocks

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When lava cools after a volcanic eruption, tiny magnetic minerals inside the rock can “lock in” the direction and strength of Earth’s magnetic field. This process, called thermoremanent magnetization (TRM), happens as the rock cools through the Curie temperature of these minerals. In this poster, we use concepts from condensed matter physics — such as magnetic domains, Curie temperature, and domain alignment — to explain how this magnetic memory forms and why it can last for millions of years. We focus on common volcanic minerals like magnetite (Fe_3O_4), and discuss how grain size, cooling speed, and mineral structure affect the quality of the recorded signal. To link theory with observations, we also highlight how simple computational methods, such as density functional theory (DFT), can be used to calculate magnetic moments in these minerals.

Accurate eruption forecasting: will multi-scale simulations help?

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Abstract

Given that fracture connectivity governs the movement of magma and volatile substances, understanding these processes is vital for predicting eruption styles and associated hazards. The state-of-the-art is to: 1) identify mechanisms by which fractures facilitate magma flow, 2) analyze how percolation thresholds influence magma and gas escape, and 3) evaluate their implications for volcanic hazard assessment. This review synthesizes findings from theoretical and numerical studies, including, modelling magma transport through a 15 km volcanic dike in Iceland by Sigmundsson and co-workers[1], demonstrating that tectonic stresses and even modest overpressures can sustain flow rates exceeding 7400 m³/s when pathways are fully open. Secondly, Crozier and co-workers [2], had demonstrated earlier that fracture-mediated gas escape can prolong effusive eruption phases in rhyolitic systems; and Dingwell and co-workers [3], also showed that the percolation threshold for bubble–melt connectivity varies strongly with magma rheology, ranging from $\approx 17\%$ porosity in brittle, crystal-rich magma to $>37\%$ in ductile melts. The outcome of this review reveals a complex relationship between fracture openness and transport efficiency. The following are noteworthy about the state-of-the-art about magma transport; some systems flow freely once a path exists, while others remain sealed until critical porosity or stress is reached. This review underscores that coupling fracture mechanics with percolation theory, incorporating magma viscosity, crystallinity, and stress conditions, suggesting a need for multi-scale simulations to improve eruption forecasting and hazard mitigation strategies.

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Seismic Activity Assessment and Monitoring in and around Lake Kivu

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Abstract

Lake Kivu, located on the border between the Republic of Rwanda and the Democratic Republic of Congo, lies within the tectonically and volcanically active western branch of the East African Rift Valley. With a depth of up to 485 meters and a surface area of approximately 2,400 km², the lake is globally unique due to its stable stratification that traps large quantities of dissolved biogenic methane (CH₄) and carbon dioxide (CO₂) in its deep waters below 280 meters. Estimated to hold about 55 km³ of methane and 250 km³ of carbon dioxide under standard temperature and pressure (STP), Lake Kivu poses both a valuable energy resource and a significant geohazard[1].

The concern arises from historical precedents such as the catastrophic limnic eruption of Lake Nyos in Cameroon, which released a massive cloud of CO₂ in 1986, resulting in 1,746 human fatalities and the death of 3,500 livestock[2]. Given the potential for a similar event in Lake Kivu, seismic activity assessment and continuous monitoring are critical. Earthquakes or volcanic activity could destabilize the lake's stratification and trigger a sudden gas release.

This study presents a comprehensive seismic activity assessment and evaluates ongoing monitoring efforts in and around Lake Kivu. It emphasizes the role of seismic monitoring in understanding subsurface dynamics, detecting early warning signals of tectonic or volcanic unrest, and mitigating the risk of limnic eruptions. Strengthening regional seismic networks and hazard preparedness is essential to protect the densely populated areas surrounding the lake and to ensure the safe exploitation of its gas resources.

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Atmospheric dispersion of SO₂ from Nyiragongo volcano

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Nyiragongo volcano of the East African Rift is among the most active sulfur dioxide (SO₂) emitters on Earth. Considering the environmental and health impacts of volcanic SO₂, understanding its dispersion is essential. In this study we used FALL3D dispersal model to simulate SO₂ emissions from Nyiragongo 2021 eruption by inserting satellite data in the model to improve its accuracy. We found that the SO₂ dispersion was majorly influenced by the regional wind patterns with the plume spreading mainly towards the western part of the volcano, in Democratic Republic of Congo (DRC) but also in Western and Northern Rwanda and traveling as far as Tanzania.

The study also mentions the effects of SO₂ emissions on air quality, public health, and environmental pollution, including acid rain and fluoride contamination of rainwater. The comparison of model simulations with satellite observations demonstrated the importance of using satellite data in improving model dispersion forecasts. The results can be used in volcanic hazard planning, emphasizing the need for enhanced monitoring and early warning systems in the region.

Abstract

Tectonic Reevaluation of West Cameroon domain: Insights from High-Resolution Gravity Models and Advanced Edge Detection Methods

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The West Cameroon region, characterized by a diverse geomorphology of highlands and plains resulting from tectonic processes across different geological ages, has been extensively explored for natural resources. Recognizing the significance of its tectonic and magmatic features associated with seismic and volcanic activity, this study focuses on geodynamic investigations of the Cameroon Volcanic Line (CVL). Despite previous efforts, detailed structural geophysical studies of the West Cameroon domain have proven inconclusive, prompting a comprehensive structural reinterpretation. Utilizing the high-resolution SGG-UGM-2 satellite gravity model and innovative processing techniques, our research aims to enhance the interpretational quality of tectonic lineaments. By separating regional and residual anomalies in the Bouguer gravity map and applying a combination of filters to delineate geological units, the BHG filter emerges as a robust tool that highlights subsurface edges without generating false features. This approach unveils previously undetected NNW-SSE-oriented lineaments, confirming the presence of deep fractures and faults in Bafoussam, Nkongsamba, and along the Benue Trough, corroborated by newly discovered NNW-SSW trending lineaments. The study suggests that the region's topography is overcompensated by deep mountain roots and compressive tectonism. Digitizing the BHG filter produces a structural map, revealing predominant NE trends in identified geological margins, including NNE-SSW, N-S, NW-SE, E-W, and NE-SW directions. Geological contacts between granite and high-grade gneiss are indicated by NNW-SSE and NNE-SSW trending lineaments along the Benue Trough. These results contribute significantly to the understanding of the tectonic setting of the West Cameroon Domain in general and the CVL in particular.

Keywords: Western Cameroon domain, Cameroon Volcanic Line, gravity, geological structures.

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