ID: 9

Limitaciones para calcular las condiciones pre-eruptivas en magmas mezclados y asimilados: Perspectivas del volcán La Malinche, México

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Las condiciones pre-eruptivas de los eventos eruptivos plinianos del Holoceno-Pleistoceno del volcán La Malinche, México, siguen siendo incomprendidas. Las erupciones del Holoceno de La Malinche, Pómez Huamantla (>45000 años), Pómez Malinche I (21500 años) y Pómez Malinche II (12000-9000 años) son relevantes para la evaluación de riesgos volcánicos debido a su comportamiento explosivo y su cercanía con poblaciones como Puebla y Tlaxcala (2 millones de personas en un radio de 30 kilómetros). Presentamos el resultado del cálculo pre-eruptivo para los eventos plinianos de La Malinche mediante geotermobarómetros como anfíboles, óxidos de Fe-Ti y *melt inclusions* alojadas en fenocristales de plagioclasa. Además, comparamos diagramas de fases, datos de geotermómetros y resultados de química mineral con casos de la literatura. La petrografía de fragmentos de pómez en todos los depósitos muestra un ensamblaje mineral formado por plagioclasa, biotita, anfíbol y óxidos de Fe – Ti con características de desequilibrio como texturas de tamiz, zonificación y reabsorción. Con base en nuestra evidencia, sugerimos que los magmas de La Malinche reflejan procesos complejos de mezcla y asimilación magmática. Dada la naturaleza de no equilibrio de las rocas de La Malinche, este cálculo tradicionalmente debería descartarse, sin embargo, en este trabajo demostramos que es posible determinar condiciones pre-eruptivas mediante cálculos en fases fenocrísticas en sistemas desequilibrados, considerando que estos minerales alcanzan el equilibrio en etapas antes de la mezcla y/o asimilación. Además, determinamos que los magmas del volcán debieron almacenarse aproximadamente a 7.7-10.3 km enmarcados a 200±70 MPa y a una temperatura de 820±10 °C.

ID: 31

Evidencia de migración de magma a partir de tomografía sísmica 4D para el Complejo volcánico Chiles-Cerro Negro, Frontero Colombia-Ecuador.

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En agosto de 2013 se detectó una importante actividad sísmica en la región del Complejo Volcánico Chiles-Cerro Negro que desencadenaron una crisis con sismos que fueron sentidos por los residentes de las poblaciones vecinas a la frontera entre Colombia y Ecuador. En 2023, el Servicio Geológico Colombiano (SGC) y el Instituto Geofísico de la Escuela Politécnica Nacional (IG-EPN, Ecuador) instalaron una red cooperativa de monitoreo de estaciones sísmicas de banda ancha, inclinómetros electrónicos y estaciones de GNSS. Desde el inicio en operación de la red sísmica hasta marzo 2023 se tienen en catálogo más de un millón de sismos volcano-tectónicos (VT). Se destaca el registro de sismos con magnitudes de 5,6 y 5,7 (ML). Adicionalmente, se han identificado sismos de actividad de fluidos especialmente con un incremento en la actividad a partir de 2022 aunado a un incremento en la deformación vertical de la superficie.

La evolución temporal de los focos sísmicos y la presencia de sismos de baja frecuencia sugieren fuertemente que una intrusión magmática está en curso. Este proceso se pudo evidenciar a partir de inversiones tomográficas repetidas (4D) usando cinco subconjuntos de datos seleccionados en diferentes intervalos de tiempo entre 2014 y 2023, en los que se denota una migración de magma hacia el volcán Chiles. Se interpreta que el campo de esfuerzos compresivos regional y la falta de un sistema de conductos volcánicos recientemente activos son responsables de la dificultad del ascenso magmático hacia la superficie y con ello del inicio de una actividad eruptiva.

ID: 45

Estudio de Sismicidad en la Región de La Caldera de La Primavera, Jalisco. México.

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Se presenta un estudio de la sismicidad en la Caldera de la Primavera realizado dentro del marco del proyecto P24 del CeMIEGeo, se instaló una red sísmica local con 25 estaciones Obsidian y sismómetros Lennartz-3D de período corto en la Caldera de La Primavera. El arreglo fue rectangular de 5 x 5 estaciones y una separación de 2-3 km entre cada una, durante un período de 4 meses (septiembre del 2017 a diciembre del 2017) para estudiar la sismicidad asociada con la Caldera y las estructuras tectónicas cercanas. El evento local de mayor magnitud ocurrió el 3 de septiembre del 2017 al NW de la ZMG. (M_L = 3.8). Se utilizó el software HYPO71 y el modelo de velocidades VJB01 modificado, se obtuvieron 234 localizaciones para la región respectivamente, y 65 eventos ocurridos al interior de la Sierra de La Primavera. Se observó la presencia de un grupo de 13 eventos con solución de mecanismo de falla inversa al sur de la Caldera de La Primavera, en la base del Domo Las Planillas. Así mismo, se realizó el análisis espectral de los sismos y se clasificaron, identificándose 11 eventos de tipo volcanotectónico dentro y en la orilla sur de la caldera, con contenido espectral en el rango de 5-10 Hz. Se observaron 2 eventos profundos de baja frecuencia con frecuencias dominantes de entre 1 y 5 Hz. Para el resto de los 51 eventos se observaron firmas espectrales congruentes con eventos de tipo tectónico.

ID: 75

Estimating recharge volumes and timescales from plagioclase zoning patterns

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Magma recharge events are commonly invoked as eruption triggers, but many (perhaps most) events do not cause eruptions. Understanding why recharge events do or do not initiate eruption requires knowledge of the intensive parameters (e.g., pressure, temperature, compositions, dissolved volatiles, presence/absence of exsolved volatiles) as well as the volumes of the host and intruding magmas. Various petrological and geochemical techniques are often used to describe intensive parameters, but quantification of recharge volume generally remains elusive. For some well-monitored systems, geodetic observations and modeling can constrain recharge volumes, but such techniques only apply to presently active and monitored systems. Here, we propose a new petrological technique for estimating recharge volumes using major and trace element zoning patterns in plagioclase phenocrysts. Briefly, we use major element compositions of plagioclase to quantify the temperature record within crystals, with core-to-rim distances as proxies for time. Trace element diffusion profiles within the crystal constrain crystallization timescales and thus convert core-to-rim distance into time. Together, the major and trace element profiles provide a temperature-time series of crystallization, with recharge events marked by positive temperature excursions (T_r) from a background temperature (T_o). We model the transient temperature evolution of the intruding and host magma bodies as a function of recharge volume with initial T_r and T_o indicated by the plagioclase compositions, and estimate the likely recharge volume by finding a best fit of the modeled to observed temperature-time series.

ID: 81

Multiscale seismic tomography studies of volcanoes of Kamchatka

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For more than ten years, in collaboration with several institutions, we have deployed several temporary seismic networks in active volcanic areas of Kamchatka. The data of these networks together with the data of permanent stations of Kamchatkan Branch of Geophysical Survey are used for systematic investigations of the magma plumbing system in a depth range from the mantle to the uppermost crust. The regional-scale tomography studies provide the information about the shape of the slab below Kamchatka. In these models, we identify the location of a slab window determining the activity of Shiveluch and Klyuchevskoy group of volcanoes. Middle-scale tomography models below the Klyuchevskoy group and Central Kamchatka reveal the paths of fluids and melts in the mantle wedge bringing the material for the volcanic activity. The crustal-scale models beneath selected active volcanoes give the shape of shallow magma reservoirs that are responsible for their ongoing eruption activity. For example, a local-scale tomographic model of Bezymyanny shows the state of the volcano a few weeks before a strong explosive eruption. Another model was constructed for Avachinsky Volcano, for which we clearly map the shape of the magma reservoir at a depth of ~2.5 km below surface. The information about the magma sources can be used to estimate the temperature field and to identify the most perspective locations for exploitation of geothermal energy.

ID: 91

Nuevo aporte de magma en el volcán Nevado del Ruiz para el período 2018-2023

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En 2015 el volcán Nevado del Ruiz (VNR) entró en un proceso eruptivo(emplazamiento de un domo) que continúa hasta la fecha (octubre 2023). El proceso eruptivo se caracteriza por erupciones menores frecuentes. A partir de 2021 se observó una persistencia en las anomalías térmicas en el fondo del cráter detectadas a través de satélites, así como un aumento en las señales sismo-acústicas asociadas a explosiones al interior del cráter, y aumento en el tremor volcánico, y una leve deformación de la superficie.
Esta actividad se incrementó a finales de marzo de 2023, con el registro del mayor número de sismos diarios jamás alcanzado en el VNR desde que se inició su monitoreo en 1985. Las anomalías térmicas presentaron valores similares a las registradas durante el emplazamiento del domo en 2015, lo que indicaba posible material magmático cerca a la superficie.
A partir de tomografías sísmicas 4D de tiempos de viaje de ondas de cuerpo para dos períodos (2018-2020, 2021-2023) , se pudo observar la migración de nuevo magma desde la parte SW del cráter (4-5 km de distancia) hacia una zona más cercana al mismo (1.5 km de distancia). Este ascenso y migración de nuevo magma estuvo acompañado de un incremento en las emisiones de ceniza, así como sismicidad localizada en varias fuentes sismogénicas alrededor del cráter y en el cráter mismo. Con el nuevo aporte de magma debajo del cráter activo se incrementa la probabilidad de una erupción mayor en el VNR.

ID: 227

Pump-probe monitoring of the Mount St. Helens magmatic system using slow fault slip and receiver functions

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Mount St. Helens is the most active volcano in the Cascadia volcanic arc. To forecast its future eruptions, we need to understand the evolution of the trans-crustal magmatic system in response to applied forcings. We take advantage of the unique subduction zone geometry to perform a pump-probe monitoring study of the Mount St. Helens magmatic system. In particular, we use slow slip events on the nearby Cascadia megathrust as a periodic forcing on the volcanic system, and use receiver functions to probe the velocity structure below the volcano at a range of strain conditions. This scheme enables rheological characterization of the magmatic system between eruptions.

Seismic velocity monitoring has emerged as a useful tool for monitoring magma transfer and pressurization, particularly in the shallow subsurface, but we need new methods to monitor deep magmatic processes and to detect localized changes in the plumbing system. Receiver functions (RFs) provide a localized measurement of the crustal column. With over 1500 M>5.0 teleseismic earthquakes every year, RFs permit quasi-continuous monitoring of the whole transcrustal plumbing system.

We build a catalog of 27,000+ RFs using M>5.0 teleseismic earthquakes from 2009-2020. During slow slip on the nearby Cascadia megathrust, we measure significant changes in the receiver functions. We localize the velocity perturbations to the upper-crustal magma chamber and the lower-crustal storage zone. This provides a direct representation of the strength of the magma relative to the surrounding crust. We discuss the potential for in situ geophysical characterization of melt rheology.

ID: 267

Constraining links between seismicity and eruptive processes at Mt. Etna during the Decamber 2018 flank eruption.

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Volcanoes provide a high level of uncertainty to local populations, and often vary in eruptive style and duration. Determining whether future euptions will be explosive or effusive is key for risk mitigation. Volcanic seismicity is a powerful tool to monitor volcanic activity, providing information on volcanic structures and subsurface processes such as magmatic fluid transport. Mt. Etna is the largest volcano in Europe and is monitored by a substantial seismic network; this provides an ideal location to quantitatively constrain links between eruptive styles and seismicity.

During periods of intense seismicity, many events go undetected. Repeating earthquakes are events that have identical waveforms, implying that they are from the same origin and mechanism. A matched filter search identifies repeats of template events, including those which are hidden behind the noise. Categorisation of seismicity into different families will establish a framework that can be linked to subsurface processes and structures, providing a quantitative comparision with the vast and complex eruptive history of Mt. Etna.

Here we focus on an increase of seismicity during the December 2018 flank eruption. 483 template events were passed though a matched filter search, detecting over 30,000 events. A progression of detected events from individual templates suggests an evolution of the seismic signal though different stages of the eruption. Precise relocations of the expanded catalogue will decipher whether the process is stationary or moving with time, allowing further constraints to be linked with subsurface mechanisms and how this relates to the monitored surface activity.

ID: 340

Tectonic control of magma emplacement and spatio-temporal magma evolution in the Michoacán-Guanajuato Volcanic Field, Mexico.

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The Michoacán-Guanajuato Volcanic Field (CVMG) is one of the world's most extensive regions of monogenetic volcanism. Its activity began in the late Pliocene and continues active until now. In some parts of the volcanic field, alignments of volcanoes are found parallel to regional fault systems, assuming a close relationship between volcanism and tectonism. The direct study of the feeder dikes has allowed us to attest to the complexity and importance of their study. Here, the regional stress field controls the orientation of magmatic intrusions, generally perpendicular to the minimum compressive stress ($\sigma 3$). However, in some parts of the volcanic field, their emplacement is influenced by the local stress field or pre-existing tectonic structures, whether or not perpendicular to $\sigma 3$ at the time of the intrusion. Moreover, the CVMG has a clear structural control in the spatio-temporal distribution, morphology, magma volume, and eruptive dynamics of volcanism. For instance, the points of maximum extension are related to greater volumes of magma, controlling the distribution of the largest volcanoes. Small changes in stress, magma pressure, flow rate, or volatile content could alter the geometry and arrangement of the feeding system, with important implications for eruptive dynamics and volcanic hazards. Therefore, understanding the magma feeder system in monogenetic volcanoes is essential to identify the factors that control their emplacement and to be able to forecast their trajectory along the crust.

ID: 350

Revealing Volcanic Insights: Harnessing Data, Algorithms, and Collaboration for Safer Communities

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To mitigate volcanic hazards, observatories and research institutions must efficiently manage and interpret diverse and growing monitoring data. This requires an efficient near-real-time data processing system critical for robust interpretation, enabling timely decision-making, and providing recommendations to authorities, civil protection agencies, and stakeholders, particularly during volcanic crises.

The preliminary results presented in this study stem from a project designed to enable direct comparisons between different volcanoes. This is achieved through the rigorous testing and refinement of existing automated computer algorithms, with the objective of creating a generalized and standardized model of volcano-seismic unrest.

Our approach involves analyzing diverse datasets from volcanoes with varying geological settings and types of volcanic activity. We aim to create a unified model capable of processing and extracting standardized information extraction from continuous waveform data, identifying common patterns across volcanoes and linking them to specific volcanic processes. To overcome this challenge, we explore novel data processing techniques, some of which are introduced here.

A pivotal aspect of our project is the development and dissemination of open-source tools and training programs. At the observatory level, this promotes data automation and consistent interpretation. On a broader scale, it enhances our understanding of volcanic processes, improving eruption forecasts, strengthens mitigation efforts, and enabling informed and timely decision-making during crises. This contributes to economic sustainability and, most importantly, ensures safer communities. Furthermore, our project aligns with global initiatives by contributing standardized open products to WOVOdat, fostering collaboration and knowledge-sharing in the scientific community.

ID: 620

Needle in the Haystack – How Pattern Recognition Techniques Applied to Continuous Volcanic Tremor Can Help Us Unravel Volcano-Internal Processes

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In many observatory settings, volcano-seismic activity is one of the key monitoring parameters. Recent machine learning approaches use either trained (on event data) or untrained methods to discover hidden patterns within continuous tremor from a volcano. Pattern recognition may help discover internal processes and ideally lead to more reliable forecasts. The success of these methods highly depend on the choice of interpretable descriptors (*features*) of the signal. Also, to be computationally tractable, most approaches use compressed measures of seismic energy (RSAM), and a subset of features describing the overall signal. Such presets may limit the potential information revealed by the very rich and complex seismic signal.

Here we experimented with a pattern recognition approach applied directly to (almost) raw continuous records using a comprehensive feature library. We focus specifically on processes associated with lava-dome extrusion at phreatic and magmatic systems, to help characterise magmatic processes and recognise early any short-term changes within the system. Our case-studies include Whakaari (White Island, New Zealand), Redoubt and Augustine volcanoes (Alaska, USA) and Volcán de Colima (Mexico). This resulted in better characterisation of emergence, periodicity and acceleration of drumbeat events associated with lava dome extrusion, cooling and impending collapse and/or explosive activity than previously possible through conventional monitoring techniques. These observations, coupled with numerical support from individual feature value time series, could help us decipher, quantify and monitor movement of magma and evolution of new pathways at dry and wet volcanic systems.

ID: 628

Análisis de actividad superficial sin precursores evidentes: El caso de la erupción (2016-2022) del Complejo volcánico Nevados de Chillán, Chile

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En enero del 2016, el Complejo volcánico Nevados de Chillán inició un ciclo eruptivo de 7 años de duración, cuya actividad fue monitoreada continuamente a través de una robusta red instrumental multiparamétrica, mostrando fases explosivas, efusivas y mixtas de variadas magnitudes. Se registraron columnas eruptivas mayores a 3.5 km de altura, 8 flujos de lava y 4 domos con composiciones entre 63.72-67.34% SiO_2, y CDP de ~2 km de alcance. Aunque sus fases han sido acotadas en términos de peligros, el monitoreo volcánico fue desafiado por la alta variabilidad y traslape de posibles precursores con la actividad en curso, disminuyendo la correlación entre las señales instrumentales y la dinámica superficial.

Para comprender su evolución, se establecieron niveles de efusividad según el volumen emitido y explosividad según alturas de columna y frecuencia de ocurrencia. Los puntos de inflexión fueron precedidos por cambios en el flujo de SO2, ciclos de alzamiento y variaciones de aumento y/o disminución de energía sísmica. Exceptuando, 4 puntos que no tuvieron precursores claros, además de los eventos máximos.

De este modo, se realiza la reconstrucción de la diferenciación magmática, modelando con AlphaMelts1.9, de los flujos de lava Sebastian(2008), Domo 1(2017), L1(2019) y L5(2020) y la implicancia en su dinámica superficial e instrumental ¿Qué periodos de actividad instrumental corresponden entonces a cada cuerpo magmático?¿qué relación existe con la actividad explosiva simultánea? Nuestro trabajo muestra el uso complementario de datos instrumentales y modelos de ascenso magmático en ciclos eruptivos extensos para mejorar la detección temprana de actividad volcánica.

ID: 701

Caracterización de la actividad explosiva del volcán Sabancaya entre el 2022 y 2023 a través de registros acústicos

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El volcán Sabancaya está ubicado en Perú en la zona volcánica de los andes centrales, actualmente se encuentra en proceso eruptivo desde el 2016 y se caracteriza por registrar varias explosiones al día, así como emisiones continuas de ceniza y gases volcánicos. Desde el 2022 el Observatorio Vulcanológico del INGEMMET – OVI implementó una red de monitoreo acústico (ubicado a 2.6 km del volcán) en tiempo real, que permitió la detección de más de 3000 señales acústicas asociadas a la actividad superficial, para la determinación de los eventos se contrasto con registros sísmicos y cámaras de video-vigilancia. Dentro de las características más resaltantes fue el rango de frecuencias predominantes calculadas entre 0.4 y 3.2 Hz, así también el registró de dos subtipos de señales, con inicios impulsivos asociados a explosiones discretas y con inicios emergentes y duración sostenida, asociados a explosiones con tremor. Por otro lado, se observó periodos de incremento en las amplitudes de las señales acústicas asociadas al ascenso de magma cercano a la superficie y periodos de disminución de las mismas relacionadas al emplazamiento de domos de lava. Finalmente, se determinó la variación de la profundidad de las explosiones presentadas como eventos acoplados caracterizados por el registro de dos señales: la primera asociada al ascenso final de magma, y la segunda a la generación de la explosión; las profundidades para periodos con domos fueron superficiales entre 0.5 y 3km respectivamente, y para periodos de destrucción de domos más profundos entre 1 y 7 km.

ID: 279

The late Holocene Nealtican lava-flow field, Popocatépetl volcano (Mexico): Emplacement dynamics and future hazards

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Popocatépetl, one of the most hazardous volcanoes worldwide, poses significant threats for nearby populations. Therefore, it is important to reconstruct its eruptive history, including estimates of lava-flow emplacement times and their rheological properties. These studies define possible future eruptive scenarios and are necessary to mitigate the risk. Stratigraphic studies of the cal 350–50 B.C. Lorenzo Plinian pumice sequence indicate that effusive activity (Nealtican lava-flow field) occurred shortly after explosive activity, reflecting drastic changes in the eruptive dynamics. This was likely due to the efficient degassing of the magma during the Plinian phase and a decrease of magma ascent and decompression rates. Magma mixing, fractional crystallization, and minor crustal assimilation are the processes controlling the differentiation of the Nealtican lavas. Analysis of chemical and mineralogical composition allowed us to estimate lava-flow viscosities. By using high-resolution elevation data it was possible to estimate emplacement times. Results indicate that lava viscosities of andesites and dacites ranged from 10^9 to 10^{12} Pa·s and emplacement durations between ~1 and ~29 years, depending on the flow unit and morphological method employed. Considering the entire volume of emitted lava (4.2 km^3) and a mean output rate of ~1 m^3/s to ~15 m^3/s, we estimated that the effusive phase that produced the Nealtican lava-flow field may have lasted ~35 years. This eruption had a considerable impact on pre-Hispanic settlements around the volcano, whose population exodus and relocation probably contributed to the rise of important cities in central Mexico, such as Teotihuacán and Cholula.

ID: 28

Localisation and Characterisation of volcanic high-frequency tremor above 10 Hz on Mount Etna

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Mount Etna lies in a heavily populated area and the understanding of its volcanic processes are therefore of great interest.

As for low frequency ranges (below 5 Hz) its tremor is well investigated. Such tremor signals can often be linked to magma movement. However, little is known about seismic tremor on Mount Etna above 10 Hz. Adressing this, a large field campaign in summer 2022 was undertaken consisting of the deployment of arrays of seismic nodes installed around the summit craters leading to the detection of tremor bands between 10-20 Hz as well as the typical tremor signals below 5 Hz.

The high-frequency tremor varies strongly in intensity over time periods of one hour whereas the tremor below 5 Hz is relatively constant. This suggests that frequencies above 10 Hz could be a separate signal due to a process not yet fully understood.

Localisations of this tremor point to the Bocca Nuova Crater which was degassing at the time. By comparing envelopes of seismic data with acoustic data from the same field campaign we try to understand possible relationships between the level of ongoing degassing and the observed seismic tremor. Is it tied to the degassing activity? Or is there little correlation found between acoustics and seismics suggesting different source-processes?

In summer 2023 we undertook a complementary deployment of seismic, acoustic and optical camera data at Bocca Nuova. With the help of this multi-parametric dataset we try to constrain possible source-processes generating high-frequency tremor.

ID: 189

Laboratory insights on volcano stability and triggering following earthquakes.

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Volcanic edifices are often found near tectonic margins and are built from the accumulation of both effusive and explosive materials. As a result, they are highly heterogeneous and subjected to repetitive earthquakes and pose significant threats as they may become unstable. Here, we investigate the mechanics of volcano stability using a suite of 47 uniaxial laboratory experiments to investigate the development of damage in mechanically loaded volcanic rocks subjected to the passage of rapid, low-amplitude mechanical oscillations (such as those observed during earthquakes). We monitored the accumulation of damage during the experiments with acoustic emissions sensors. Additionally, we quantified post-experiment damage by characterising the pressure dependence of permeability, using Scanning Electron Microscope imaging, and by tracking the change in acoustic velocities through each sample. Our results demonstrate that both the amplitude and the repetition of mechanical oscillations accentuate the accumulation of damage inside the samples as they contained more micro-fractures than rocks only subjected to creep deformation (i.e., deformation under constant load). We conclude that the formation, growth, and coalescence of micro-fractures may provide transient pathways for the migration of fluids (i.e., pore pressure variation) in the hydrothermal system. Ultimately, we discuss that the variation of pore pressure may also lead to further hazards such as the triggering of phreatic or magmatic eruptions and edifice instabilities such as the one at Unzen volcano, Japan following the M_w 6.4 earthquake in 1792; or the collapse following the M_w 9.1 Tohoku earthquake in 2011, still responsible for the exclusion zone today.

ID: 247

Understanding the evolution of magma systems between two supereruptions to support inter-agency planning and unrest response

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The two youngest supereruptions in the central Taupō Volcanic Zone (TVZ), Whakamaru (349 ka) and Ōruanui (25.4 ka), have been extensively studied but the tempo and nature of volcanism in the Taupō-Maroa area between these two events is less documented. Eruptives spanning this period have been studied using petrology and dating in collaboration with emergency managers, mana whenua (sub-tribe that has authority) and GeoNet volcano monitoring through the Caldera Advisory Group. There were six magma systems in existence from 349-25.4 ka, which in turn had deeper crustal roots reflecting two crustal greywacke terranes. Lavas of the Western Dome Belt age-bracket the Whakamaru event and reflect a long-lived magmatic system that was seemingly independent of the much larger Whakamaru system. To support risk management and the interpretation of modern unrest through CAG we have found that lava dome distributions in the area are influenced by tectonic structures and dome eruptions occur more frequently than previously thought, suggesting the most probable eruptive mode of rhyolitic caldera volcanoes is smaller dome-building eruptions. Temporal and spatial patterns of large explosive versus dome-building eruptions in the central TVZ during the 349-25.4 ka period strongly imply that the extreme thermal fluxes needed to drive magmatic systems for the large explosive eruptions varied greatly in intensity and moved around over a ~80 x 40 km area. This knowledge assisted with calibration of probabilities of the range in future scenarios during the recent 2022-23 unrest at Taupō, that led to the first ever supervolcano volcanic alert level rise.

ID: 304

Spatial and temporal variation of the Q coda during the pre-eruptive phase of Tajogaite eruption.

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Time-lapse monitoring of seismic velocity in volcanic regions is crucial for understanding volcanic dynamics and temporal changes in volcanic systems. Ambient Noise Interferometry is one widely used technique for monitoring subtle variations in the subsurface. This method quantifies relative velocity changes (dv/v) by analyzing shifts in the phase of cross-correlated ambient noise signals. In this research, we go beyond velocity and investigate the significance of the temporal variations in the intrinsic seismic attenuation in volcano monitoring. This quantity is computed from the Q-coda (Qc) derived from ambient noise cross-correlation data.

The Qc is determined using the lapse-time dependence method, where this parameter is assessed as a function of the coda window length for various onset times of ambient noise cross-correlation coda. We apply this method to the 2021 Tajogaite eruption in La Palma, Canary Islands, which commenced on September 19 and had significant societal and scientific implications. Initially, we established a reference Qc model for the Cumbre Vieja volcano using data collected from August 1 to 31, 2021. Subsequently, we examine the spatio-temporal variations in Qc during the nineteen days leading up to the eruption and compare these results with previously obtained dv/v findings.

Our analysis reveals an increase in Qc during the pre-eruptive phase is synchronous to a decrease in dv/v. We propose that this correlation may be attributed to the ascent of hydrothermal fluids toward the surface before the eruption. This observation highlights the potential relevance of Qc as an additional parameter for automated volcano monitoring alongside dv/v.

ID: 385

Volcanic rocks can indicate when eruptions will end: geochemical and mineralogical time series trends in lavas, Tajogaite, La Palma, 2021

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Volcanic sequences, rocks, and crystals record direct evidence of magma system dynamics that prime, drive, modulate and halt eruptions. However, applying petrological insights from old deposits as a basis for real-time forecasting has been hampered by a lack of sufficiently complete multi-disciplinary data streams from the same eruption that might allow breakthroughs in common understanding and translatable signals across sub-disciplines. Here we report geochemical and mineralogical time series trends from simultaneously erupted effusive lava and explosive tephra; these reveal the physical evolution of the magma plumbing system that drove, sustained, slowed, and finally halted the 2021 eruption of Tajogaite, Cumbre Vieja, La Palma, Canary Islands. Causative links are established between the petrological record and real-time monitoring signals including seismicity, ground deformation and lava discharge rate. Magma was evacuated in a sequence from shallow storage to deep sourced and from high to low mobility. The collapse of crystal mush layers as the magma reservoir was exhausted was signalled by a steadily increasing residual melt component first observed ~2 weeks before the eruption ended. The production of temporally well-constrained petrological data and integration of results across sub-disciplines will enhance understanding of specific eruptions. This will underpin a new frontier in deterministic crisis management and has clear potential for more effective hazard assessment with implications for forecasting the end of eruption and mitigation of increasing global volcanic risk.

ID: 412

The value of time-lapse gravity monitoring at active volcanoes in Ecuador

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Cotopaxi volcano began a new eruption in October 2022. This renewed activity produced minimal changes before eruption. Since 2015, a monitoring network with seven gravimetry stations was established around Cotopaxi´s base. Considering travel time between stations, stabilization, measurement time at each station, day loops at Cotopaxi consist of occupation of three stations.

Further northward, the Chiles-Cerro Negro Volcanic Complex (CCN-VC), a stratovolcano with no historical eruptions, is located on the Ecuadorian-Colombian border. Two seismic swarms were associated with seismic activity of >2000 EQ/day, which began in May 2022, and initially concentrated at the S base of Chiles. Later, a second swarm evolved 15 kilometers SE at Potrerillos Caldera. This is a complex zone with regional faults crossing beneath the volcanos. In March 2023 another swarm kicked in with >5000 VT earthquakes/day and up to +90 mm/yr of vertical deformation. At CCN-VC we established two monitoring networks each with six gravimetry stations; the first one immediately south of Chiles and the second one located nearer to Potrerillos Caldera.

The results of the latest gravimetry campaigns in Cotopaxi show changes on the order of 64 mGal. CCN-VC also shows maximum change of up to 33 mGal at the CHGE station. Preliminary interpretation is that these changes are due to drying out of the hydrothermal system.

In summary, gravimeters serve as an essential tool in volcano monitoring and enable scientists to detect substantial changes that provide critical information about magma movement, buried faults and other subsurface changes, such as in the hydrothermal system.

ID: 451

Lava emplacement and eruptive history of scoria cone Piedra de Chinos, Sangangüey region: implications for future hazards

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The western sector of the Mexican Volcanic Belt contains 5 polygenetic volcanoes with Holocene-Pleistocene eruptions. One of them is the Sangangüey volcano, active since ca. 300 ka, in its surroundings has multiple monogenetic vents of dacitic to basaltic-andesitic compositions. The Piedra de Chinos scoria cone, is one of them, located on the northwestern slope of the volcano. Through a careful morphological analysis and mapping of the surface features of its lava flows, a reconstruction of the emplacement processes was carried out. Piedra de Chinos is a 126 m-high basaltic scoria cone built on a dacitic dome. It has a horseshoe-shape crater from which eight lava flows erupted. Strombolian and effusive activity occurred simultaneously during the emplacement of the first lava flows, but apparently declined with the last one, which allowed breach the cone and dragged part of it. The lava flows had a range of 3.4 km, for the first emitted lava flow, and 0.4 km for the last one, the thickness increases as their length decreases, the amplitude of each flow ranging from 1.6 km for flow 5 to 0.05 km for the flow 8B. The total volume of the effusive products was 0.107 km^3. According to the morphological characteristics of each flow, the estimated emplacement times yield between 11 to 14 months for the entire eruption. These results are the starting point for the creation of hazard maps for a hypothetical scenario of lava flows emitted by a new monogenetic eruption in the region.

ID: 509

Seismicity and Deformation Accompanying Eruption Cycles at Basaltic Caldera Volcanoes in the Galápagos Islands, Ecuador

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Large basaltic volcanoes offer natural laboratories to study the fundamental processes of crustal deformation and seismogenesis. High rates of magma flux in to and/or out of shallow reservoirs can result in strain rates and stress regimes that seldom occur in purely tectonic settings. Eruptions at the basaltic caldera volcanoes of the Galápagos Islands, Ecuador, are often associated with particularly high amplitudes and rates of deformation, and correspondingly high rates of seismicity. Variations in location with respect to the centre of the Galápagos plume, regional structural features, and the other volcanoes, provides each system with a particular set of characteristics in terms of edifice morphology and eruptive behaviour. By understanding how these characteristics also influence the nature of seismicity, we expect new insights into the mechanisms of shallow magma emplacement, edifice deformation, and earthquake generation. Here we describe the seismicity that occurred before, during, and after recent eruptions at Sierra Negra and Fernandina volcanoes. Earthquake rates, locations, and statistics document distinct processes of magma accumulation and withdrawal, influenced by the geometry of the shallow plumbing systems and edifice structure. The nature of seismicity is, in turn, distinct from that observed at recent eruptions in Hawaii and Iceland, and in non-volcanic tectonic settings. These observations reveal how stress evolves on intra-caldera fault systems, how lateral magma intrusion is accommodated in the absence of prominent rift-zones, and some of the factors which determine whether or not caldera collapse occurs.

ID: 555

Preliminary investigation of fluids emitted from Eldfell volcano (Iceland)

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In this study we report the results of a survey carried out in 2021 on the Eldfell volcano (Iceland).

The main aims were to i) identify the main structures where fluids and heat are released, ii) define the origin of the emitted fluids, and iii) quantify the magmatic CO_2 emissions into the atmosphere.

More than 400 measurements of ground temperature and CO_2 flux from soil were performed in two main areas: i) the fissure zone from which the 1973 eruptive event started, and ii) the entire volcanic edifice. In addition, gas samples were collected from selected sites for the recognition of the carbon isotopic signature in CO_2.

The fissure zone is characterized by a ground temperature close to the ambient temperature and a very low CO_2 flux. In contrast, anomalous ground temperatures (T_{max}=104.5°C) and relatively high (1595 g m^{-2} d^{-1}) diffusive CO_2 fluxes from the soil were recorded in the crater area.

Gas vents at the summit of Eldfell volcano are highly contaminated by atmospheric gas, whereas CO_2 undoubtedly has a magmatic signature, as revealed by the carbon isotopic ratios expressed as $d^{13}C_{CO2}$ values.

The diffuse CO_2 flux from soil, computed only for the summit area, has been estimated to be approximately 1,0 ±0,1 ton per day. The aforementioned value, which is significantly lower than the levels observed in other dormant volcanoes, serves as a benchmark for future research endeavours pertaining to Eldfell volcano

ID: 756

Classification, textures and eruption history of the youngest lava dome in the Tatun Volcanic Group, northern Taiwan

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Tatun Volcano Group (TVG), located nearby the capital of Taiwan, is a Quaternary andesitic-dominated active volcano. Due to the large population of surrounding cities (ca. 7 million people) and the close distance to two nuclear power plants, the volcanic hazards of TVG could cause catastrophic impact on life and enormous economic losses. Mt. Shamao is likely the youngest known event in the TVG has significant implications for the characterization of volcanic hazards at Tatun volcano. Therefore, this study uses volcanic morphology, petrology, lithofacies and Ar-Ar ages to clarify and reconstruct the type, textural, eruptive history and to speculate on the potential hazards of Mt. Shamao.

The results suggest that Mt. Shamao is a Peléean-type lava dome. The eruption history can be divided into three phases: the first phase was a small-scale effusive eruption at 183.7 Ka, which resulted in the fan-shaped, two-pyroxene andesite lava flow that located on the southwestern side of the dome. After the eruption ceased, the remaining magma in the magma chamber becomes more acidic and viscous due to fractional crystallization.. At 15 Ka, another eruption occurred, resulting in the formation of the two-pyroxene hornblende andesite main body and the crater texture of the dome. Eventually, as the magma became more acidic, small domes formed and filled in the craters left by the second-stage eruption and retained the crease structure.

ID: 543

Reconstructing the Neapolitan volcanism prior to the 39.8 ka Campanian Ignimbrite: results from a scientific drilling north of Naples (Italy)

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In the framework of the INGV–Pianeta Dinamico research theme TIFEHO (**T**rachytic **I**gnimbrites magma-chambers **F**ormation and **E**volution in the pre-**HO**locene history of the Campania volcanic area), whose main goal is understanding the growth and evolution of the deep magmatic feeding system prior to high magnitude eruptions originated from the Neapolitan volcanic area, a deep scientific drilling has been performed, down to 113.2 m below the ground, north of Naples (Italy), in order to investigate the volcanic stratigraphy prior to the 39.8 ka Campanian Ignimbrite (CI) eruption, the largest caldera-forming event originated from Campi Flegrei (CF). Most of the cored succession consists of a thick pyroclastic sequence older than the CI and pertinent to the explosive activity of the Campi Flegrei volcanic district. The stratigraphic analysis of the cored sediments allowed to identify thirty-one pyroclastic units older than CI, having thickness between 0.13 and 21.5 m, separated by well-developed paleosols and/or reworked volcaniclastic deposits. This pyroclastic succession consists predominantly of massive to stratified pyroclastic current deposits, both magmatic and phreatomagmatic, and minor coarse- to fine-grained fall deposits. Some units clearly exhibit features compatible with a proximal vent such as coarseness, lithic enrichment, and considerable thickness, while a number of units may represent products emplaced during low energy eruptions or distal tephra layers possibly sourced from the Island of Ischia. The retrieved stratigraphic record highlights a remarkable explosive activity >40 ka, the study of which will allow the achievement of a better detailed knowledge of the CF magmatic system.

ID: 654

OBSERVING AND MODELLING FERNANDINA VOLCANO DEFORMATION WITH ECUADORIAN VOLCANO SAR IMAGERY UNTIL SEPTEMBER 2023

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The use of remote sensing has been very important in order to study volcanoes that are located in areas that are difficult to access with in situ instruments such as tiltmeters or c-GPS stations. Nowadays SAR imagery has provided data that can be analyzed with InSAR time series for analysis which have aided in monitoring Ecuadorian Galapagos volcanoes.

Specifically, imagery from the satellite system Sentinel-1 of the European Space Agency, were taken over consecutive time periods (every 12 days) and corroborated unrest and ground displacements at Fernandina volcano. We processed coherence, velocity maps and time series plots in order to monitor volcano activity.

The 2020 eruptions at Fernandina were preceded by displacements detected by InSAR time series. The LOS displacement velocities at these volcanoes are 80 cm/year during 2020 to 2023. In the last processing results we do not identify acceleration or another anomaly that could suggest a possible imminent eruption..

Applying DModels software to model the geometry of the source of deformation can give us an order of magnitude about the volume of eruption. We tried with a penny shape, spherical and spheroid geometries. We compared the goodness of fit of models using chi-square parameters; we determined that a spherical shape is the most suitable geometry of the observed data. Additionally, we derive a volume of 25 million cubic meters per year, at a depth of ~1 km, located at the south east cuadrant of the caldera.