EXHIBITION ENTRY [ENTRADA EXPOSICIÓN]

For 85 days the Cumbre Vieja volcano emitted 200 million cubic metres of ash and lava, changing landscapes and lives on La Palma.

During this time, the scientific staff worked tirelessly at the volcano to reveal its secrets.

TIMELINE [LÍNEA DEL TIEMPO]

This is the graphic representation of a chronological sequence of events, processes or occurrences that have taken place regarding a given topic over a certain time period.

For instance, timelines can be used to organise the different historical epochs of humanity: Prehistory, Ancient Times, Middle Ages, Modern Times and Contemporary Times.

HOW DOES IT WORK? [¿CÓMO FUNCIONA?]

Turn the pyramid module on your right up or down to see the different lines.

VEGEOLOGICAL TIME SCALE [ESCALA TEMPORAL GEOLÓGICA]

This is a framework for representing the events of the history of life on Earth in chronological order. The divisions are based on the type of life that dominated each period according to the fossil record and on major physical disturbances that occurred on the planet. The established divisions are:

- **Superaeon**: informal division of the geological time scale grouping several aeons together.
- **Aeon**: Earth’s longest span of time, fixed according to the development of complex life forms.
- **Era**: a long interval of time defined by the type of life that prevailed on Earth.
- **Period**: a subdivision of an era characterised by major disturbances on the planet. It is further subdivided into smaller units not shown here.

GEOLOGICAL AND HISTORICAL CONTEXT [CONTEXTO GEOLOGICO E HISTORICO]

Subdivided into two: the first is from 30 million to 15 million years ago, and the second from that time to the present day.

It shows outstanding information on the geological history of the Canary archipelago, and of La Palma in particular, as well as historical and archaeological milestones of global importance that have been passed since the appearance of the human species.
FORWARD COMMAND POST [PUESTO DE MANDO AVANZADO]

The forward command post worked around the clock to monitor the volcano’s activity and coordinate the operation mobilised by the eruption. In tents like this, there was constant multidisciplinary activity. As if it were a brain, data collected in real time converged on this space, analysis of which was crucial for the authorities’ decision-making.

The emergency teams also had technical and scientific support in carrying out their work and, as far as possible, attending the demands of the national and international media who had been attracted to the island by the eruption. Restricted access to the exclusion zone turned the scientific staff into regular reporters for the press, radio and television, a reach amplified by the social networks where the material they recorded with their mobile phones had enormous impact.

SCIENCE ON LAND [CIENCIA EN LA TIERRA]

The eruption on La Palma opened the door to hitherto unpublished research. One project was the possibility to follow, for the first time, how the effects of the eruption process on biodiversity developed in real time. Among other conclusions, the studies found that plants and animals benefited from resilience linked to ecological and evolutionary trends in island environments. Examples of this are the adaptation of the Canary Islands pine tree to high temperatures, the strength of woody plants, or the flexibility of vertebrate animals to changes in diet.

Another focus of study was to estimate the extent of damage caused by ash deposition on the island’s crops. From the first days after the eruption, ash samples were continuously collected and analysed in selected areas close to the volcano. In addition to determining ash composition, the researchers sought answers to other questions: what would happen with the water leached through the ash after irrigation and rainfall, how it would affect the physical and chemical fertility of the soil, and what would be its impact on fruit ripe for harvesting and human consumption.

TEXT FOR MICROSCOPE SPECIMENS [MUESTRAS EN MICROSCOPIO]

Thin basanite sections. The samples correspond to aa and pahoehoe lava flows from other eruptive times. They were collected with thermal gloves and cooled in a metal pan with water.

Basanite is a rock that has alternating zones with an aphanitic texture, where crystals are indistinguishable to the naked eye, and porphyritic, with larger crystals that are directly visible. It also has a considerable number of vesicles (gas bubble spaces) as a result of degassing, which can be up to 10%.

The samples consist of a mineral association of clinopyroxene, magnetite and olivine. Amphibole is also present. These minerals are embedded in a glassy matrix with abundant microcrystals of plagioclase, lime and olivine, some of which show frequent irregular fractures without alteration or small amounts of epidote, a material produced by the weathering of olivine. Amphiboles and clinopyroxenes form large crystals with straight edges, with clear zoning.

Collection date: 09/11/2021
Collection area: Playa de los Guirres (La Palma, Spain)
Collector: IEO-CSIC
The first steps to ensure the safety of the population near the eruption involved the demarcation of evacuation and exclusion zones. The many dangers inherent in an eruption such as on La Palma are diverse. High temperatures near lava flows require the use of appropriate protective equipment. Inhalation of volcanic gases can cause respiratory problems or even death, and some, such as hydrochloric (HCl) and sulphuric (H₂SO₄) acid gases, cause burns to the skin and mucous membranes on direct contact. There are also hazards posed by pyroclasts, such as the risk of impact from falling blocks and volcanic bombs, or lung and eye damage from exposure to ash. To all this we must add the direct destructive capacity of the lava flows, the possibility of acid rain, landslides caused by the accumulation of ash and lapilli or those caused by earthquakes accompanying the eruptive process.

The personal protective equipment to which the pandemic had accustomed us was again the norm during the eruption but with variations adapted to the new situation: helmet, goggles, masks with specific gas filters and protective footwear and high-visibility clothing. Additionally, in the case of sample collection, chemical and thermal protective suits and gloves became essential.

The emergency teams also had technical and scientific support in carrying out their work and, as far as possible, attending the demands of the national and international media who had been attracted to the island by the eruption. Restricted access to the exclusion zone turned the scientific staff into regular reporters for the press, radio and television, a reach amplified by the social networks where the material they recorded with their mobile phones had enormous impact.

The team responsible for the geological surveys used echo sounders, a high-resolution mapping tool to identify depth and structures associated with changes in seafloor morphology. These were mapped daily to assess the advance and growth of the lava flows.

Oceanographic studies were performed to detect variations in water properties, such as temperature, salinity, dissolved oxygen or inorganic nutrients, among other parameters. An oceanographic rosette was used for this purpose, equipped with various sensors and bottles for collecting water samples at various depths. These samples also permitted microbiological studies to quantify the impact on phytoplankton communities and other marine microorganisms of the massive influx of lava, cinders and ash into the sea.

For water sampling, a rosette of oceanographic bottles was used to obtain samples at different depths, and also to measure some parameters continuously with various sensors. Analysis of these samples can identify physico-chemical anomalies in the water or changes in the planktonic communities due to lava flow, ash or underwater thermal emissions.

An unmanned Underwater Vehicle or ROV was also used, the Liropus 2000. The use of this ROV made it possible to capture high-definition images of the underwater lava flow and to take rock and near-bottom water samples for analysis of chemical and biological parameters.
The scientific monitoring of the eruption had an unexpected ally: the drone. Although there are no specific models designed for volcanoes, there are geologists who fly them and who are able to make a scientific reading of their images even during the recording. They literally became the eyes of the research staff, capable of flying to less than 100 m from the volcanic cone and barely 35 m from lava flows, practically entering the mouth of the crater. In addition to avoiding endangering people’s lives, they also provided images and data of crucial interest for science and for emergency management decisions.

Another aspect of the air that was studied in detail was its quality. From the point of view, the case of La Palma is also unique, because never before had information on air quality during an eruption been collected in such detail. Chemical analysis of the samples showed that the composition of respirable particles (smaller than 10 microns diameter), consisted of soot or magma debris, dust from the Sahara on days when such haze arrived, soot from diesel vehicles and fires, organic carbon of varied origin and salts deriving from volcanic acids.

**DRONES IN THE SERVICE OF SCIENCE**

Two types of drones were used to monitor the volcanic conventional, camera drones and thermal drones. The latter were especially useful not only for flying at night, but also during the day, because the infrared and thermal cameras revealed the state of the crater and the lava flows, to know if they were still active or starting to cool. The drone pilots decided to use DJI Mavic Enterprise Dual Drone plus radio control and Sky monitor DRONE MODELS that melted as it flew at low altitude over the lava flows and crater.

**SCIENCE IN THE AIR [CIENCIA EN EL AIRE]**

The crises of poor air quality during the volcanic eruption on La Palma required an innovative field work and monitoring data analysis. A CSIC team provided scientific support and advice for air quality monitoring at the Canary Islands Government stations.

The CSIC team carried out respirable aerosol concentration measurements in different parts of La Palma, which consisted of:

- Mobile measurements of PM10 and PM2.5 along numerous transects, or cuts, through El Paso, Los Llanos and Tazacorte. PM stands for particulate matter, and the subscript numbers indicate whether the diameter is less than or equal to 10 or 2.5 microns, respectively.
- Continuous measurements of fine and ultrafine particles and black carbon in Los Llanos.
- Chemical analysis of respirable PM10 in El Paso and Los Llanos.

The information obtained was shared daily with the Canary Islands Government and RIVOLCO, in order to take decisions aimed at protecting the health of the population. General recommendations included the use of P2 masks, goggles, long-sleeved clothing and avoidance of outdoor physical activity. In the most adverse scenarios, confinement of local residents was advised.

The tool shown here was used in the mobile measurements, which transects, were made between Tazacorte and El Paso to identify the areas where air quality was better or worse.

**RESPIRABLE PARTICLES [PARTÍCULAS RESPIRABLES]**

The total concentration of respirable particulate matter PM10 were below 20 micrograms per cubic metre ($\mu$g/m3), reasonably good between 20 and 40, fair between 40 and 50, highly unfavourable between 100 and 150 and extremely unfavourable when above 151 $\mu$g/m3. During the eruption, most of the respirable particles consisted of ash, tephra or volcanic magma.

**COMPOSITION OF RESPIRABLE PARTICULATE MATTER [COMPOSICIÓN DE LAS PARTÍCULAS RESPIRABLES]**

This graph shows the chemical composition of respirable PM10 particles taken in El Paso and Los Llanos during different periods. The coloured bars show the contribution of each source of respirable particles, having in mind the nature of volcanic emissions.

Air quality was good when concentrations of respirable particulate matter PM10 were below 20 micrograms per cubic metre ($\mu$g/m3), reasonably good between 20 and 40, fair between 40 and 50, highly unfavourable between 100 and 150 and extremely unfavourable when above 151 $\mu$g/m3. During the eruption, most of the respirable particles consisted of ash, tephra or volcanic magma.
PYROCLAST FORMATION (FORMACIÓN DE PIRÓCLASTOS)

Eruptions in the Canary Islands are not normally very explosive, mainly Strombolian, which involves a pyroclastic cone near the eruptive mouths and lava flows. The morphology of these lava flows varies from a simple palo de hierba, to more complex, as on Tenerife. Pyroclasts are formed by fragmentation of magma due to the rapid or explosive expansion of bubbles formed by gases separating out from the magma during their ascent to the surface. Pressure inside the gas bubbles builds up and eventually ruptures, breaking up the magmatic liquid film surrounding them. This explosion generates fragments known as pyroclasts, classified according to their size as ash (smaller than 2 mm), lapilli (between 2 and 64 mm) and bombs or blocks (larger than 64 mm).

During the La Palma eruption, the vents emitted some 200 million cubic metres of material and the lava flows covered 1,219 hectares of ground a few kilometres from the eruptive mouths. The pyroclastic eruptions were mainly strombolian, with an emission source, moving around the summit, from which the eruption proceeded to form a pyroclastic cone near the eruptive mouths. The lahars that originated from the eruption were mainly those of the pyroclastic cone, which was the eruption source. The pyroclastic cone was located in Fissuritas, making it impossible to use the solid ash transported from sea level. The eruption column was 6.5 km from the main cone to the sea. This eruption was a consequence of the collapse of the magma chamber under the summit, which caused it to crack and break apart.

PYROCLAST COLUMN (COLUMNA DE PIRÓCLASTOS)

This column is a valuable testimony of the evolution of the eruption process. It shows changing intervals of material, reflecting the different phases and stages of volcanic activity. Thus, at the base of the column, which corresponds to the first weeks of the eruption, ash layers are deposited. Later layers of ash alternate with coarser pyroclast layers, depending on the type of material thrown up by the volcano through time.

Analysis of the data provided by monitoring with geophones, sensors that record seismic and seismo-acoustic waves, enables correlating geophysical data with the morphology of the pyroclastic deposits in parallel, as shown in the column.

[CENIZA Y LAVA] REVELACIONES CIENTIFICAS JUNTO AL VOLCÁN

| Collection area: Tajuya (La Palma, Spain) | Collector: MUNA | Date of collection: 14/11/2021 | Weight: 1 kg |
| Collection date: 14/11/2021 | Collection area: Tajuya (La Palma, Spain) | Collector: MUNA | Date of collection: 14/11/2021 | Weight: 1 kg |
| [Cola cordada] Corded lava flow | When the surface of the lava cools and deforms plastically without breaking, it adopts wave or ovoid forms as shown. The grey fragment was transported over the surface of the lava flow as it advanced. |
| Collection date: 27/10/2021 | Collection area: Camino de la Cruz Chica (La Palma, Spain) | Weight: 1.8 kg | Collector: IPNA-CSIC |
| [Lava aa or malpais] As lava or malpais | Dough-surfaced lava, with irregularly shaped blocks and sharp sides. The surface cools quickly, which causes it to crack and break apart. |
| Collection date: 10/11/2021 | Collection area: Salinas de Fonsendaite (La Palma, Spain) | Weight: 0.3 kg | Collector: MUNA |

| Collection area: Tajuya (La Palma, Spain) | Collector: MUNA | Date of collection: 14/11/2021 | Weight: 0.3 kg |
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| [Sal contaminada] Contaminated salt | When the surface of the ash cools and deforms plasticly without breaking, it adopts wave or ovoid forms as shown. The grey fragment was transported over the surface of the ash as it advanced. |
| Collection date: 04/03/2022 | Collection area: El Paraiso (La Palma, Spain) | Weight: 0.1 kg | Collector: IPNA-CSIC and University of La Laguna (ULL) |
| [Basalto alterado] Altered basalt | Samples of lava fragments covered with patinas of iron oxides and hydroxides deriving from hydrothermal processes. |
| Collection date: 06/03/2022 | Collection area: Las Manchas, between the road to San Nicolás and the Cabeza de Vaca road (La Palma, Spain) | Weight: 0.1 kg | Collector: IPNA-CSIC |

| Collection area: Las Manchas, between the road to San Nicolás and the Cabeza de Vaca road (La Palma, Spain) | Collector: IPNA-CSIC and University of La Laguna (ULL) | Date of collection: 06/03/2022 | Weight: 0.1 kg |
| [Bomba 3.] Bomb 3 | The sample on the right has a reddish hue due to a higher content of iron oxides and hydroxides. |
| Collection date: 04/03/2022 | Collection area: vicinity of the crater of the volcano Cumbre Vieja (La Palma, Spain) | Weight: 8.5 kg | Collector: IPNA-CSIC |

| Collection area: vicinity of the crater of the volcano Cumbre Vieja (La Palma, Spain) | Collector: IPNA-CSIC | Date of collection: 04/03/2022 | Weight: 8.5 kg |
| [Bomba 2.] Bomb 2 | The sample on the right has a reddish hue due to a higher content of iron oxides and hydroxides. |
| Collection date: 10/11/2021 | Collection area: Salinas de Fonsendaite (La Palma, Spain) | Weight: 0.3 kg | Collector: MUNA |

| Collection area: Salinas de Fonsendaite (La Palma, Spain) | Collector: MUNA | Date of collection: 10/11/2021 | Weight: 0.3 kg |
| [Taxopúmulo] Taxopúmulo | Rock resulting from the interaction of a magma of basic (alkaline) composition that melts, incorporates and cools, generating in the ocean floor. These materials are richer in silica and lighter due to their large number of vesicles, which allows them to float on water for a considerable time. |
| These rocks are unstable at magmatic temperatures (800 - 1000 °C), when the erupted magma from the surface, allowing a clear differentiation between the white mottled inner materials and the dark outer areas, which are the magma that carries them. |
| Collection date: 05/03/2022 | Collection area: vicinity of the crater of the volcano Duraznero (La Palma, Spain) | Weight: 8.5 kg | Collector: IEO-CSIC |

| Collection area: vicinity of the crater of the volcano Duraznero (La Palma, Spain) | Collector: IEO-CSIC | Date of collection: 05/03/2022 | Weight: 8.5 kg |

| CARTOUCHE FOR EACH SAMPLE | CIMA DE LAVA ALREDEDOR DE PINOS |
| [Molde de tronco] Log mould | When the surface of the lava has cooled and deformed plastically without breaking, it adopts wave or ovoid forms as shown. The grey fragment was transported over the surface of the lava as it advanced. |
| Collection date: 15/12/2021 | Collection area: Los Mochales, between the road to San Nicolás and the Cabeza de Vaca road (La Palma, Spain) | Weight: 7.1 kg | Collector: IPNA-CSIC |

| Collection area: Los Mochales, between the road to San Nicolás and the Cabeza de Vaca road (La Palma, Spain) | Collector: IPNA-CSIC | Date of collection: 15/12/2021 | Weight: 7.1 kg |
| [Molde de tronco y agujero] Log mould and hole | When the surface of the lava has cooled and deformed plastically without breaking, it adopts wave or ovoid forms as shown. The grey fragment was transported over the surface of the lava as it advanced. |
| Collection date: 10/11/2021 | Collection area: Salinas de Fonsendaite (La Palma, Spain) | Weight: 0.3 kg | Collector: MUNA |

| Collection area: Salinas de Fonsendaite (La Palma, Spain) | Collector: MUNA | Date of collection: 10/11/2021 | Weight: 0.3 kg |
CENIZA Y LAVA
REVELACIONES CIENTIFICAS DEL NUEVO VOLCAN

FACE WALL
(INTRODUCTORY TEXT)
This wall introduces you to the scientific staff from the CSIC and other institutions whose contributions have made the ‘Ceniza y Lava’ (Ash and Lava) exhibition possible. The science of the La Palma volcano has many more faces and names, from the CSIC and other organisations. Our exhibition goes to all those who carried out (and continue) research on the eruption.

Notably, the environmental workers of the Cabildo de La Palma (Island Council) and to all the volunteers who helped and facilitated the work under very difficult conditions.

VERÓNICA PÉREZ MÉNDEZ
DOCTOR IN BIOLOGICAL SCIENCES - University of Granada (UGR)
Institute of Natural Products and Anthropology (IPNA-CSIC)
I took data and samples for the documentation and study of the environmental changes caused by the eruption of the volcano. During the eruption, or priority was to record as much environmental and volcano-tectonic data as possible. We also advised the emergency managers. These data allow us to develop and use the limits of new numerical physics models that have predictive capabilities. Such models allow us to predict when there will be more explosive phases or when an eruptive event will end, and to name a few of their applications.

MAÍRA MERCEDES HERNÁNDEZ GONZÁLEZ
DOCTOR IN BIOLOGICAL SCIENCES - University of La Laguna (ULL)
Institute of Natural Products and Anthropology (IPNA-CSIC)
I study the fertility of agricultural and horticultural soils, and farms located on the slopes of Cumbre Vieja. I have obtained a record of the chemical composition of the air, temperature, and atmospheric conditions of the area. This work was carried out simultaneously with the eruptive process under extreme environmental conditions. Subsequently, once the eruption was over, this monitoring has continued in the affected areas in order to study its sequels.

JUANA VEGA
DOCTOR IN GEOLOGICAL SCIENCES - University Complutense de Madrid (UCM)
Spanish Geological and Mining Institute of Spain (IGME-CSIC)
I am a field scientist at the Emergency Geological Response Unit (URGE). During the eruption, I was in charge of studying all the geological changes caused by the eruption of the volcano on Cumbre Vieja. I have led studies of the variations in physico-chemical, biological and geological anomalies in the crater, and the surrounding area. I have also advised the Spanish authorities on the volcanic process, a task I continue to carry out today as the emergency sequels continue.

EUGENIO FRAILE NUEZ
DOCTOR IN BIOLOGICAL SCIENCES - University of Las Palmas de Gran Canaria (ULPGC)
Spanish Institute of Oceanography (IEO-CSIC)
I am the Principal Investigator of the marine studies performed during the eruption of the volcano on Cumbre Vieja. I have led studies of the variations in physico-chemical, biological and geological anomalies in the crater, and the surrounding area. Subsequently, once the eruption was over, this monitoring has continued in the affected areas in order to study its sequels.

JOAQUÍN QUIRÓS PRIEGO
DOCTOR IN BIOLOGICAL SCIENCES - University of Seville (US)
I travelled to La Palma because the deployment of CSIC researchers in the field required real-time occupational risk prevention advice to help in decision-making and ensure the highest degree of safety for the intervention staff. I also provided advice on how to approach other entities involved in the operation.

This wall introduces you to the scientific staff from the CSIC and other institutions whose contributions have made the ‘Ceniza y Lava’ (Ash and Lava) exhibition possible. The science of the La Palma volcano has many more faces and names, from the CSIC and other organisations. Our exhibition goes to all those who carried out (and continue) research on the eruption.

Notably, the environmental workers of the Cabildo de La Palma (Island Council) and to all the volunteers who helped and facilitated the work under very difficult conditions.

THOMAS BOULESTEIX
DOCTOR IN EARTH SCIENCES - Université Paris-Saclay
Institute of Natural Products and Anthropology (IPNA-CSIC)
I supported the CSIC members on the scientific committee of the PEVOLCA (Special Plan for Civil Protection and Volcanic Eruption of the Autonomous Community of the Canary Islands) in documenting the eruption and in studying the products emitted (gases, ash, pyroclastic, etc.), their evolution and spatial distribution.

PABLO J. GONZÁLEZ
DOCTOR IN EARTH PHYSICS - Complutense University of Madrid (UCM)
Institute of Natural Products and Anthropology (IPNA-CSIC)
I am a volcanologist, a profession that involves the interpretation of data and samples from the eruption of Cumbre Vieja, as well as the construction and use of models to predict future eruptions. I was there during the La Palma eruption, and I continue to carry out this work today as the emergency sequels continue.

MARÍA JOSÉ JURADO
DOCTOR IN GEOLOGICAL SCIENCES - Universitat de Barcelona (UB)
Institute of Natural Products and Anthropology (IPNA-CSIC)
I study the fertility of agricultural and horticultural soils, and farms located on the slopes of Cumbre Vieja. I have obtained a record of the chemical composition of the air, temperature, and atmospheric conditions of the area. This work was carried out simultaneously with the eruptive process under extreme environmental conditions. Subsequently, once the eruption was over, this monitoring has continued in the affected areas in order to study its sequels.

JESÚS MARÍA ARRIETA LÓPEZ DE URALDE
DOCTOR IN BIOLOGICAL SCIENCES - University of Groningen
Search Institute of Oceanography (IEO-CSIC)
I studied the effect of pyroclastic and other volcanic material deposition on planktonic micro-organisms.

José Antonio Lozano Rodríguez
Doctor in Petrology and Geochemistry - University of Granada (UGR)
Search Institute of Oceanography (IEO-CSIC)
I was in charge of studying all the geological changes caused by the lava flows and the formation of the lava lakes. These studies were part of the VULCANA (Vulcanología Canaria Submarina) project, led by the Spanish Institute of Oceanography (IEO-CSIC) with the support of the oceanographic vessel Ramón Margalef and Angelines Alvarellos. As well as the Líneas 2000 remotely operated vehicle (ROV) for taking images and geological samples.

JANA ALONSO LORENZO
DOCTOR IN MOLECULAR BIOLOGY - Universidad Autónoma de Madrid (UAM)
Institute of Natural Products and Anthropology (IPNA-CSIC)
I have studied the impact of ash on banana crop physiology by analysing primary and secondary metabolites. Studies that are applied state-of-the-art mass spectrometry and optical and scanning microscopy techniques.

JUANA ALONSO LORENZO
DOCTOR IN BIOLOGICAL SCIENCES - University of Las Palmas de Gran Canaria (ULPGC)
I studied the effect of pyroclastic and other volcanic material deposition on planktonic micro-organisms.

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