

# Volcanology and Ecology in Nicaragua



Prof. Hazel Rymer, Open University, UK

## Overview

The well known geological hazards related to volcanoes—eruptions and landslides—can cause widespread devastation. Less well known are the ongoing or cumulative impacts associated with volcanoes that continuously emit gas and erupt at a low level, but do not usually explode. While less dramatic, over long periods of time these volcanoes can negatively impact biodiversity, impede economic development, and hinder efforts to reduce poverty in surrounding areas.

Since 1983, Prof. Hazel Rymer has conducted research at the Masaya volcano in Nicaragua, and the Poás volcano in Costa Rica. She chose these sites because they exhibit contrasting environmental conditions and persistent but low levels of eruptive activity. Earthwatch teams have contributed to the research since 2008.

The goal of *Volcanology and Ecology in Nicaragua* is to better understand the environmental and ecological hazards caused by “persistently active volcanoes,” and to develop strategies for mitigating the associated environmental and ecological risks.

Rymer is leading groundbreaking research by attempting to use different proxies to help predict when volcanoes erupt. Rymer’s team also aims to understand how volcano-derived elements (heavy metals such as copper, zinc and lead) interact with the soil, water and atmosphere. They can then assess the risks to human health, food quality, and agriculture over time. For example, heavy metals can enter the food chain once they are absorbed by edible plants—posing obvious risks to the surrounding community.

Her team is also studying the internal plumbing of persistently active

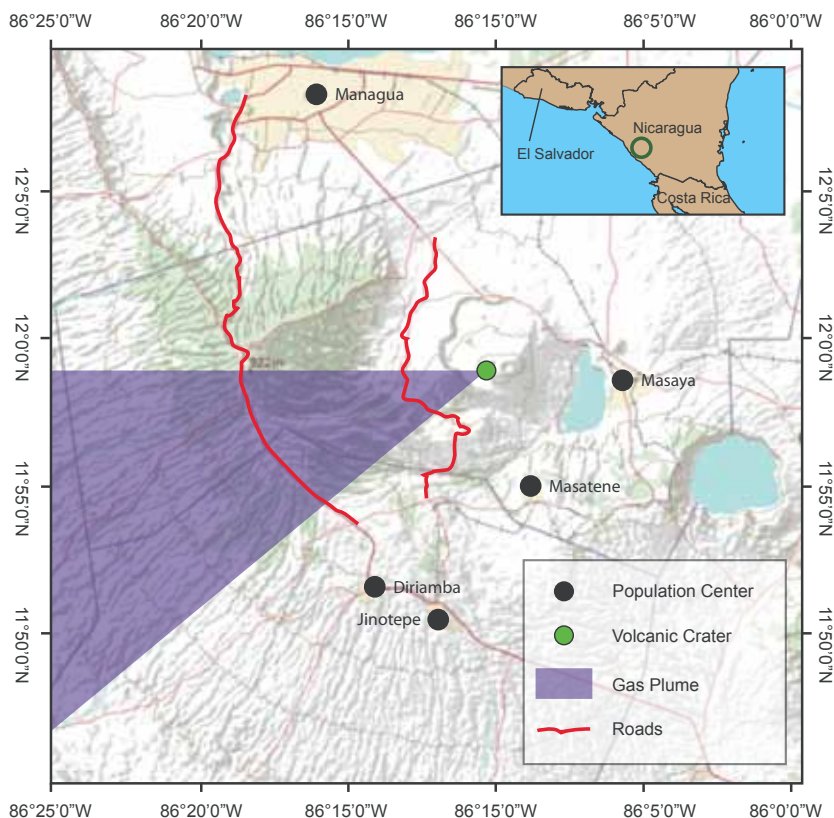


Figure 1: The Masaya volcanic crater and its surroundings. The roads marked in red are where sulfur flux is measured. The purple triangle indicates the area affected by the gas plume.

*The research is groundbreaking in attempting to use different proxies to help predict when volcanoes erupt.*

volcanoes, by recording micro-changes in gravity caused by movement of magma within the volcano. The scientists correlate these microgravity changes to the eruptive activity eventually seen at the surface. The research will quantify the emission of gases from the source magma, within the volcanic plume, and the flux and concentration of different metals into the local environment (soil, water, flora, and fauna).

Information about how heavy metals move through the ecosystem will enable the team to develop effective mitigation procedures, including recommendations

on cultivating acid-tolerant crops, and how and when to evacuate livestock.

The objectives of this project are:

- To identify the physical and chemical signatures associated with persistently active volcanoes and how they change through time
- To understand how volcanoes impact niche ecosystems, including how they impact volatile pollution levels in the surrounding areas
- To integrate geophysical/geochemical and environmental data to provide a holistic overview of the causes and effects of changes in volcanic output



Figure 2: Teams use gravity meters to study micro changes in gravity caused by movement of magma within the volcano.

## Outcomes

Three Earthwatch teams fielded in 2010. Volunteers used GPS technology, monitored volcanic gases, and deployed devices to collect geoelectric activity and gravity data.

**Microgravity results: Poás.** Prof. Rymer and her team have demonstrated that microgravity surveys are useful in predicting volcanic eruptions. Since 2004, the team has observed increases in gravity; since 2008, these increases

were followed by greater degassing and phreatic activity (minor eruptions involving water), likely indicating an impending eruption. The team established survey plots around the summit area with sulfation plates (used to estimate the deposition of pollutants in the atmosphere) and plants (used as “bio-indicators” showing change in the environment). Further geophysical measurements in 2009 underscored the increased volcanic activity at Poás. As suspected, the volcano erupted on 18 September, 2009, preventing further expeditions.

**Microgravity results: Masaya.** Similar geophysical measurements at the Masaya site in 2009 indicated this volcano to be relatively stable during the 2010 fielding season. The teams did not observe any significant changes in the gravity or gas flux signatures, and were able to set up a series of sulfation plates and leaf surveys to gather baseline data on how much sulfur is being emitted from the volcano.

In 2010, the teams observed changes in the gravity signature near Masaya’s active crater. The three northern stations—*Teatro*, *Pecho V* and *Zoplotes*—exhibited lower gravity, while the stations close to the crater on the southern side—*Edge*, *Pedro* and *Pedro II*—had higher gravity. This suggests that magma is moving towards the south side, and may indicate the location of the volcano’s next eruption. The team estimated the amount of magma accumulated to be of the order of  $10^{11}$  kilograms—a relatively small amount of magma relative to other volcanoes in the world. (Interestingly, that amount is roughly equivalent in mass to the amount of paper used in the United States every year).

In addition, while the variations between north and south across the crater diminished over time (possibly suggesting diminished volcanic activity), the mass beneath the crater decreased, which may suggest that there is a build up of gas beneath the volcano. The last time this phenomenon was observed (between 1993 and 1995), it led to a major degassing crisis causing health concerns that there may be an imminent eruption. Will it happen again? The

monitoring continues. In 2009, they also made Very-Low-Frequency (VLF) measurements in and around Masaya's crater area to provide a baseline for the 2010 field season, when the survey network was expanded to include more than 1,500 new VLF points. This method is used to detect regions of hydrothermal alteration beneath the surface, which is important because new eruptions can exploit these weaknesses. Early observations have indicated variations in the VLF signal, suggesting the formation of new fractures within the volcanic structure.

**Environmental data.** Heavy metals spewed from volcanoes can harm pollen in plants. That means certain plants can be useful bio-indicators for scientists, helping them understand the impacts the volcano has on surrounding plant life. Rymer and her team are interested in indentifying a new bio-indicator—an organism or biological response that provides an early warning of pollutants or declining health of an ecosystem—to help them gauge variations in the gas flux from persistently active volcanoes. In addition to informing short-term responses to gas-related health emergencies and medium-term land management policies that reduce the impact of degassing on human and agricultural activity, the results will eventually be incorporated into global climate change models. With the aim of trying to identify whether changes in gas fluxes are measurable in the surrounding flora, certain plant species were chosen for monitoring in 2009: the spiderworts *Tradescantia pallida*, *Arcytophillum lamarum* (weakly upright to scrambling plants), and the shrub “prickly heath,” which scientists call *Pernettya mucronata*.

In 2009, the team developed a molecular biological test to apply to the stamen hairs of *T. pallida*, to analyze for phenotypic (externally visible) mutations in a recessive gene which is expressed as flower color and chromosomal damage in pollen cells, caused by volcanic pollution. Other suitable species of flora will continue to be identified for this test.

To assess which heavy metals are being absorbed by plants and in what

*The team have demonstrated that microgravity surveys are useful in predicting volcanic eruptions.*

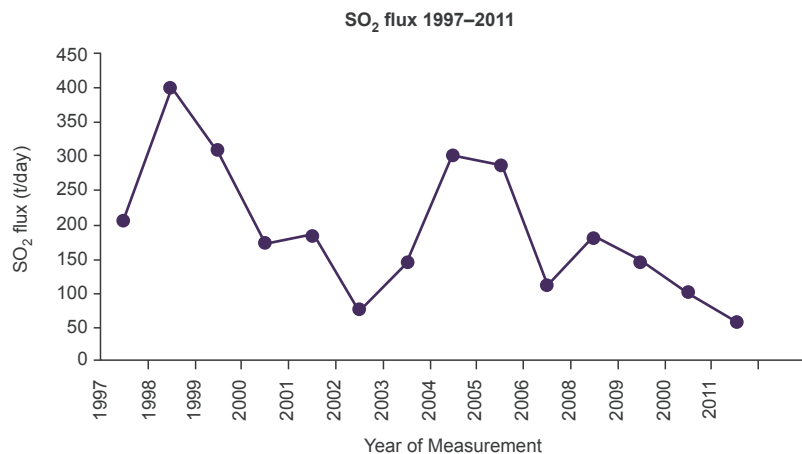


Figure 3: Graph showing the amounts of SO<sub>2</sub> gas measured at the Masaya volcano yearly from 1997 to 2011. (Data not collected in 2007.)

concentrations, samples of locally grown plant material (leaves, stems, flowers and fruits) were collected in areas surrounding the Masaya and Poás volcanoes in 2009. In 2010, these were analyzed using the inductively coupled plasma mass spectrometry (ICP-MS) method at the Open University. An ICP mass spectrometer measures precise concentrations of heavy metals in different materials. Preliminary results show that the plant material contained copper, zinc, cadmium, and lead well beyond “background,” or normal environmental levels.

During the 2010 field season, the team mapped the distribution of sulfates in the area of the crater, using the sulfation plates deployed in 2009. By understanding the local variation in sulfates around Masaya, Rymer's team can reveal an integrated picture of the effects of volcanic degassing. The distribution indicates a concentration of sulfates downwind, which they expected, but there are also subtle variations due to local (mainly topographic) conditions. Of special interest from the map was the way in which the pollution spread from the volcano's vent, to a significant distance upwind.

In 2010, an additional environmental health proxy was included in the field research: mapping the distribution of

the air plant (a plant that grows non-parasitically on another plant or tree) *Tillandsia recurvata*, which is very sensitive to atmospheric pollution. Rymer's team found that the plant species effectively mirrored the results from the sulfation plate mapping. They will establish over the coming field seasons whether this plant can be used as a proxy for volcano gas flux measurements. If air plants prove useful as proxies for volcano gas flux, this result will have major implications for monitoring persistently active volcanoes around the world.

#### Recent Publications

Rymer, H., Locke, C.A., Borgia, A., Martinez, M., Brenes, J., Van der Laat, R. and Williams-Jones, G. (2009) Long-term fluctuations in volcanic activity: implications for future environmental impact. *Terra Nova*, **21(4)**:304–309

Hinrichs, M., Rymer, H., Gillman, M. and Blake, S. (2011) Characterisation and distribution of heavy metals at Masaya volcano, Nicaragua, *American Geophysical Union*, December

Rymer, H., van Wyk de Vries, B., Stix, J., and Williams-Jones, G. (1998) Pit crater structure and processes governing persistent activity at Masaya Volcano, Nicaragua, *Bulletin of Volcanology* **59**:345–355