Report on the 13th workshop of the Commission on the Chemistry of Volcanic Gases

Franco Tassi, Santiago Arellano, Silvana Hidalgo, Artur Ionescu, María Clara Lamberti, Ryunosuke Kazahaya

The 13h workshop of the Commission on the Chemistry of Volcanic Gases (CCVG) was held from September 24th to October 3rd, 2017, in Ecuador. The meeting was attended by 67 participants from 19 countries, and supported by the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI). The meeting consisted of a main conference session held in Baños (25-27 September) with up to 23 oral and 42 poster presentations, and field expeditions at (1) the main thermal spring sites at the foothill of Tungurahua volcano (28-29 September), (2) Guagua Pichincha volcano (2 October), (3) Pululahua caldera (2-3 October), and (4) Cotopaxi volcano (2-3 October). Optional field trips to El Reventador volcano (20-23 September; 16 participants) and Galápagos Islands (5-9 October; 20 participants) were also carried out, as well as half-day seminars on different measurement techniques and some social activities

Scientific topics addressed in the oral and poster presentations represented a wide variety of volcanic gas studies, including regional studies, in-depth investigations of individual volcanic systems, new methodologies for gas studies and other topics related to volcanic gas emissions. The conference was opened by an overview presentation on volcanoes and gas monitoring in Ecuador, followed by oral presentations classified under four scientific sessions: (1) Observations and interpretations (8 oral, 18 poster); (2) Technical development (6 oral, 10 poster); (3) Volcanic gas impact (5 oral, 6 poster); (4) Multidisciplinary (4 oral, 8 poster). The full program with titles, abstracts and main authors is appended to this report.

The general seminars were divided in three sessions, covering different aspects of direct sampling, diffuse degassing and remote sensing. They were presented by experts on different methodologies and were directed to both expert colleagues and new-comers to the techniques. Social activities included an ice-breaker ceremony and tour in Quito, a visit to the Tungurahua volcano observatory and the headquarters of the Instituto Geofísico in Quito, tours to natural cascades and volcano sighting places in Tungurahua, as well as a closing dinner and party.

Prior to the field activities sessions were arranged in Baños and Quito for general planning of the logistics and calibration or preparation of equipment. The first general field expedition was conducted at thermal springs located at the base of Tungurahua volcano and was attended by most participants, with the aim of comparing sampling techniques and measurements on CO_2-rich gases collected from bubbling pools. Three thermal sites were selected for the workshop: El Salado (47°C), Santa Ana (44.4°C) and La Virgen (54.4°C). The sampling activity consisted of the collection of Giggenbach-type flasks, dry gas samples and water samples.

At El Salado site nine groups sampled dry gas, namely: GNS Science (NZ), INVOLCAN (ES), University of Napoli 2 (IT), University of New Mexico (US), Babes-Bolyai University + MTA-ELTE (RO/HU), CICESE (MX), INGV Palermo (IT), CNRS-IPGP (FR) and CEA-CNRS (FR). The University of New Mexico, INGV Palermo and University of Florence (IT) sampled soda flask and four sampled water (University of Perugia (IT), University of Napoli 2, Universidad de Buenos Aires (AR) and Babes-Bolyai University + MTA-ELTE).

At the Santa Ana site, five groups (University of Florence, INGV Palermo, University of Napoli 2, Babes-Bolyai University + MTA-ELTE and CICESE) sampled dry gas. The University of New Mexico only collected soda flask samples, while water samples were collected by University of Perugia, University of Napoli 2, CICESE, Babes-Bolyai University + MTA-ELTE, Universidad de Buenos Aires, and INVOLCAN. During the sampling of the spring IVAR (PT), INVOLCAN and the University of Perugia group conducted diffuse measurements along a transect in order to calibrate the detectors for the Pululahua caldera campaign.

La Virgen was the last site where the various groups collected samples. GNS Science, INVOLCAN, Babes-Bolyai University + MTA-ELTE, CICESE, University of Florence + University of Bologna, INGV Palermo, University of New Mexico, and CEA-CNRS collected dry gas. Soda flask were collected by four groups namely: University of New Mexico, INGV Palermo, University of Napoli 2, University of Florence + University of Bologna; and water samples by Universidad de Buenos Aires, University of Perugia, CICESE, University of Napoli 2, INVOLCAN, and Babes-Bolyai University + MTA-ELTE.

Figure 1. Photographs of fieldwork conducted at Tungurahua volcano. Sampling of several thermal springs was carried out around this volcano. A. View of Tungurahua volcano; B. Sampling of noble gases by Philippe Jean-Baptiste (CEA-CNRS) and Artur Ionescu (Babes-Bolyai University); C. Sampling of gases in soda flask by Tobias Fisher at the El Salado thermal spring (University of New Mexico); D. View of Santa Ana spring; E. Jorge Córdova (Instituto Geofísico-Escuela Politécnica Nacional) measuring dissolved CO_2 content of the spring; F. Fatima Viveiros (IVAR) and Maria Clara Lamberti (University of Buenos Aires performing soil diffuse flux measurements; G. View of La Virgen spring; H. Sampling of dry gas in Exetainer tubes by Andrea Ricci (University of Bologna); I. Carlo Cardellini (University of Perugia) measuring carbonate concentration of the spring. *(photos: Artur Ionescu, Andrea Rizzo,Dario Tedesco, Manuel Inostroza, Taryn Lopez*)

The fieldwork at Guagua Pichincha was very challenging, with many participants suffering from altitude sickness and exhaustion (altitudes above 4500 m asl and technically difficult climbing). However, all the goals for direct sampling measurements at one fumarole, elected as the official CCVG fumarole, called “La Pichincha” (~89°C), were achieved. Various groups sampled Giggenbach-type flasks (Universidad de Buenos Aires, INGV Palermo, University of New Mexico and University of Napoli 2). Babes-Bolyai University + MTA-ELTE, GNS Science, INGV Palermo, CNRS-IPGP, CEA-CNRS, University of Napoli 2, and University of New Mexico sampled dry gases; while Babes-Bolyai University + MTA-ELTE, Institute of Volcanology and Seismology FEB (RU), University of Napoli 2, and INGV Palermo sampled condensates. The Johannes Gutenberg-University group (DE) and University of Colorado (US) in addition, collected samples from air affected by fumarole emission, with different sampling devices (e.g. denuders and alkaline traps). The field expeditions resulted in many fruitful discussions and ideas for future collaborations, as well as an opportunity for veterans in gas chemistry to share their extensive knowledge with young scientists.

Figure 2. Photographs of fieldwork conducted at Guagua Pichincha volcano. Extensive direct sampling of the workshop fumarole was achieved on this challenging target. A. View of the cristal dome from the crater rim; B. Remote sensing from the crater rim by Florian Dinger (Max-Planck Institute for Chemistry) and Ulrich Platt (Heidelberg University); C. Arriving at the fumaroles; D. Sampling lines for dry gas, soda flasks and condensate; E. In situ measurements above the fumaroles by Nicole Bobrowski (University of Heidelberg); F. Group photo at the cristal dome. *(photos: Celine Mandon, Elena Maters, Francisco Vasconez, Manuel Inostroza, Allan Lerner)*

Diffuse carbon dioxide gas measurements were conducted at the Pululahua Caldera by five teams (University of Perugia, IVAR, INVOLCAN, Instituto Geofísico-Escuela Politecnica Nacional (EC) and Babes-Bolyai University + MTA-ELTE. Furthermore, samples of the soil gas were taken in order to study the isotopic composition of carbon (IVAR). In the caldera at the site named “Fuente del Pailón” bubbling pool, dry gas and water samples were collected by the following groups: INVOLCAN, Babes-Bolyai University + MTA-ELTE, University of Florence + University of Bologna, INGV Palermo, University of Perugia, and University of Napoli 2.

Figure 3. Photographs of fieldwork conducted at Pululahua volcano. A dense mapping of diffuse soil emissions and direct sampling of thermal springs were done on this caldera. A. Sampling of soil gases by Fatima Viveiros (IVAR); B. Water sampling of the Fuente del Pailon by Dario Tedesco (University of Napoli 2) and Franco Tassi (University of Florence); C. Flux measurements by Artur Ionescu (Babes-Bolyai University) and direct sampling by Marco Liuzzo (INGV Palermo), Boglarka-Mercedesz Kis (MTA-ELTE) and Andrea Ricci (University of Bologna); D. Soil diffuse measurements lead by Fatima Viveiros (IVAR); E. Soil diffuse measurements lead by Carlo Cardellini (University of Perugia); F. Soil diffuse measurements performed by Boglarka-Mercedesz Kis (MTA-ELTE) and Artur Ionescu (Babes-Bolyai University) *(photos: Taryn Lopez, Alexandra Gutmann, Francisco Vasconez)*

Although remote sensing activities were conducted at the pre-conference fieldwork in El Reventador and from the caldera of Guagua Pichincha, these were challenging targets due to difficult access to a suitable measurement location. The main target for remote sensing measurements was Cotopaxi volcano, which had an active, albeit weak plume. Successful remote sensing measurements were conducted in Volcán de Azufre during the second optional fieldwork held in Galápagos. The official fieldwork planning was done in Baños and followed by an inter calibration and preparation exercise with gas cells of SO_2, done two days before the work at Cotopaxi.

In the Cotopaxi fieldwork participated 20 people using UV SO_2 cameras (USGS (US), University of Heidelberg (DE), AIST (JP), University of Sheffield (UK), and EOS/NTU (SG); UV DOAS scanners: Chalmers University (SE), University of Heidelberg, AIST, University of Alaska/GI (US)) and DOAS/FLYSPEC mobile systems: USGS, Chalmers University, University of Heidelberg, University of Alaska/GI, and INGEMMET/OVI (PE). The fieldwork started with a traverse in the ring-road inside Cotopaxi National Park to identify the position of the plume. After detection of a

weak plume at ca. 10 km distance from the volcano in direction WNW, most groups deployed stationary camera and scanning instruments from a location NW of Cotopaxi at a distance of about five km from the plume and eight km from the crater. Weather conditions were good upon arrival with a magnificent view of the volcano, but soon afterwards turned cloudy, making remote sensing measurements challenging. The group attempted measurements between ca. 10:00 and 15:00 LT, during which a total of five complete traverses were simultaneously conducted from the inner routes on the W to N sides of the volcano. Preliminary flux evaluations indicate an SO_2 flux< 500 t/d, passively drifted by moderate winds at the altitude of the volcano's summit (5897 m asl). This is consistent with measurements conducted by the monitoring network of IG during the previous days.

Figure 4. Photographs of fieldwork conducted at Cotopaxi volcano. Remote sensing with different stationary methods and traverses under the weak plume was attempted under non-ideal weather conditions. A. Calibration of remote sensing instruments at Quito; B. Cotopaxi summit; C. Remote sensing group with stationary cameras; D. Mounting of sensors on the bus for mobile measurements by Santiago Arellano (Chalmers University of Technology) and Fredy Apaza (INGEMMET OVI); E. UV-camera for mobile transect by Andrew McGonigle (University of Sheffield); F. Mounting of mini-DOAS on truck by Jan-Lucas Tirpitz (University of Heidelberg) and Simon Warnach (Max-Planck Institute for Chemistry); G. Mounted micro-DOAS *(photos: Artur Ionescu, Patrick Allard, Manuel Inostroza, Taryn Lopez, Allan Lerner)*

At Guagua Pichincha, the University of Heidelberg, and AIST attempted remote sensing measurements from the caldera rim with SO_2 camera and DOAS traverses. At El Reventador, the University of Heidelberg, the University of Oregon, and the IG-EPN conducted measurements with MAX-DOAS, Flyspec and a thermal camera, respectively. At Volcán de Azufre, SO_2 camera measurements were conducted by University of Palermo and CNRS-IPGP, whereas scanning-DOAS was made by University of Heidelberg and Chalmers University, all from the same location on the floor of the caldera. Chalmers University and IG also conducted walking traverses with a mobile-DOAS system around the three active fumaroles. Weather and measurement location were favorable for remote and direct measurements of this fumarolic field.

The field trip to Reventador volcano provided an additional opportunity to conduct measurements under challenging conditions. These mostly consisted of remote sensing SO_2 flux measurements. A camping was organized inside the Reventador caldera in a very remote and highly vegetated area. 16 participants were able to see the volcano during 2 complete days. Weather conditions, despite some cloudiness were quite nice considering that the region is characterized by a very high humidity and strong rain. Here, in addition to the remote sensing techniques used to measure the gas composition of the plume, water samples were collected from a blue-milky ravine flowing close to the camping site (University of Colorado and Babes-Bolyai University + MTA-ELTE). CO_2 dissolved in this stream was also measured by IG-EPN.

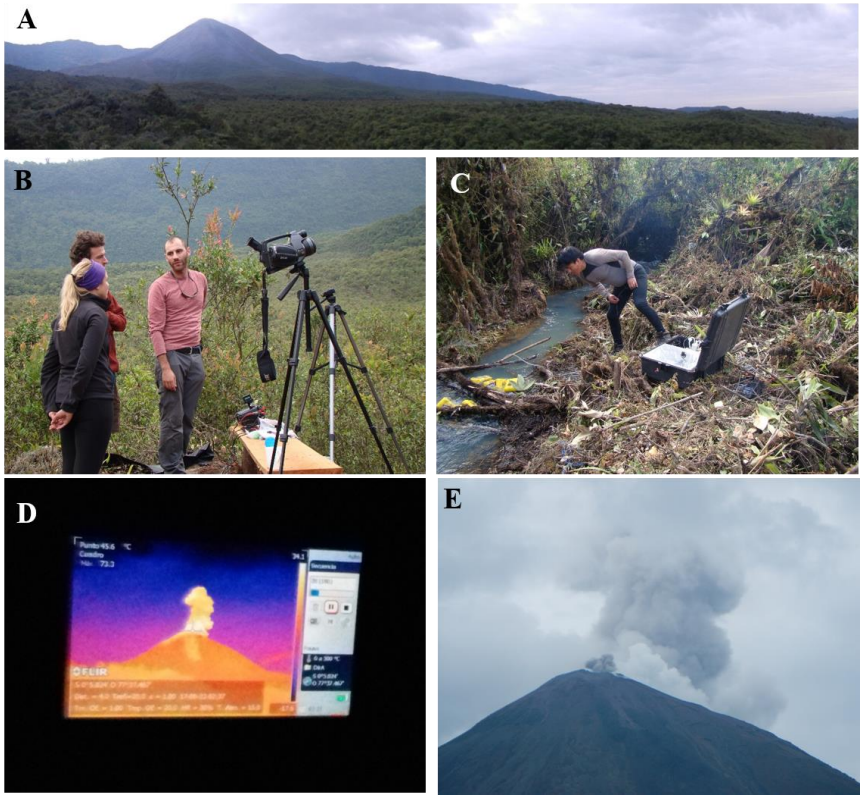


Figure 5. Photographs of fieldwork conducted at El Reventador volcano. Due to explosive activity and difficult access, only remote sensing was attempted from the caldera of this volcano. A. Panorama view of El Reventador; B. Allen Lerner (University of Oregon), Jonas Kuhn (Institute of Environmental Physics Heidelberg) and Julia Woitischek (University of Cambridge) performing remote sensing; C. Jorge Córdova (Instituto Geofísico-Escuela Politécnica Nacional) measuring dissolved CO_2 content of the stream; D. Snapshot of the thermal camera at night during an explosion; E. Small explosion and small visible plume of El Reventador *(photos Artur Ionescu)*

Fieldwork at Volcán de Azufre volcano was conducted by 20 participants on the 6 October. This started with a ca. 12 km long walk to reach the fumarolic field, under dry and hot conditions. At the sampling site three active fumaroles were studied with remote sensing (mainly SO_2 flux, see above) and direct sampling which included dry gas samples, condensates and Giggenbach-type flask were conducted by INGV Palermo, University of Napoli 2, Babes-Bolyai University + MTA-ELTE, GNS Science, CNRS-IPGP, CEA-CNRS, Institute of Volcanology and Seismology FEB (RU). The Johannes Gutenberg-University group (DE), and the University of Leeds (UK), in addition, collected samples from air affected by fumarole emission, with different sampling

devices (e.g. denuders, alkaline traps and filter packs). Additional measurements were carried out on the next day by GNS Science and the Institute of Volcanology and Seismology FEB, to complete the survey of all fumaroles.

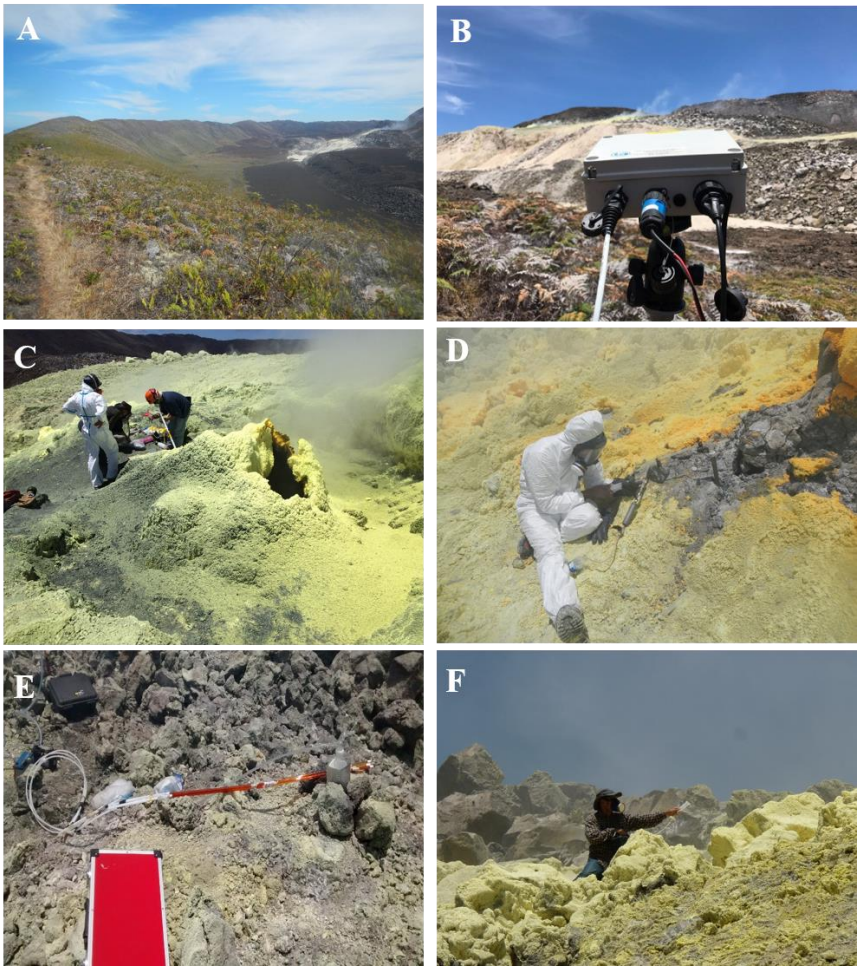


Figure 6. Photographs of fieldwork conducted at Volcán de Azufre/Sierra Negra, Galápagos. Several direct and remote sensing approaches were applied for a detailed characterization of the chemistry of volcanic gases in this basaltic volcano. A. View of Volcán de Azufre fumarolic field from the crater rim; B. UV-camera measurement; C. In-situ sampling with denuders; D. Sampling at fumarole A by Dario Tedesco (University of Napoli 2), Bruce Christenson (GNS Science) and Nataliya Malik (Institute of Volcanology and Seismology); E. Direct sampling at fumarole B by Marco Liuzzo (INGV Palermo); E. In-situ measurement with Multi-Gas by Patrick Allard (CNRS-IPGP) *(photos: Artur Ionescu, Patrick Allard, Alexandra Gutmann, Celine Mandon)*

A final meeting ending the conference and was held in Quito. Here, the future direction of CCVG was discussed in terms of memberships to the commission and the relationship between CCVG and IAVCEI, and the interactions with other IAVCEI commissions. After a brief summary of the activities carried out by CCVG in the last three years (organization of scientific sessions at international meetings, fieldtrip activities, publications), new initiatives of the group were presented.This includes: (1) a summer school on geochemical techniques to investigate volcanic gases that will be held at Caviahue (Argentina) on February 2018; (2) a scientific session at the EGU General Assembly in Vienna on April 2018 (conveners N. Bobrowki, F. Viveros and F. Tassi,); (3) a summer meeting on volcanic lakes organized in collaboration with the IAVCEI

Commission of Volcanic Lakes (leader D. Rouwet) at Monticchio Lakes (southern Italy) on June 2018; (4) the 3rd edition of the Etna International School of Geochemistry (Pizzi Deneri Volcanological Observatory, Etna volcano, southern Italy) on July 2018. In addition, announcements for special issues for the Frontiers and G3 scientific journals on advances of volcanic gas studies and on Deep Carbon Observatory results, respectively; as well as for the 6th NOVAC workshop to be held in Peru on April 2018 were presented during the conference.

A new board was elected, with Santiago Arellano and Franco Tassi as Leaders, Artur Ionescu as editor/webmaster, and Silvana Hidalgo as secretary. María Clara Lamberti was elected as editor of the Facebook page, in collaboration with Lizzette Rodriguez who constructed the Facebook CCVG group that was active in the past three years.

The site of the next workshop was also decided, with Japan, presented by Ryunosuke Kazahaya, as possible candidate. The CCVG participants enthusiastically accepted the invitation of Kazahaya to visit Japan for the 14th CCVG workshop on June 2020. Kazahaya was officially elected as Local Organizer, as a new member of the leading board.

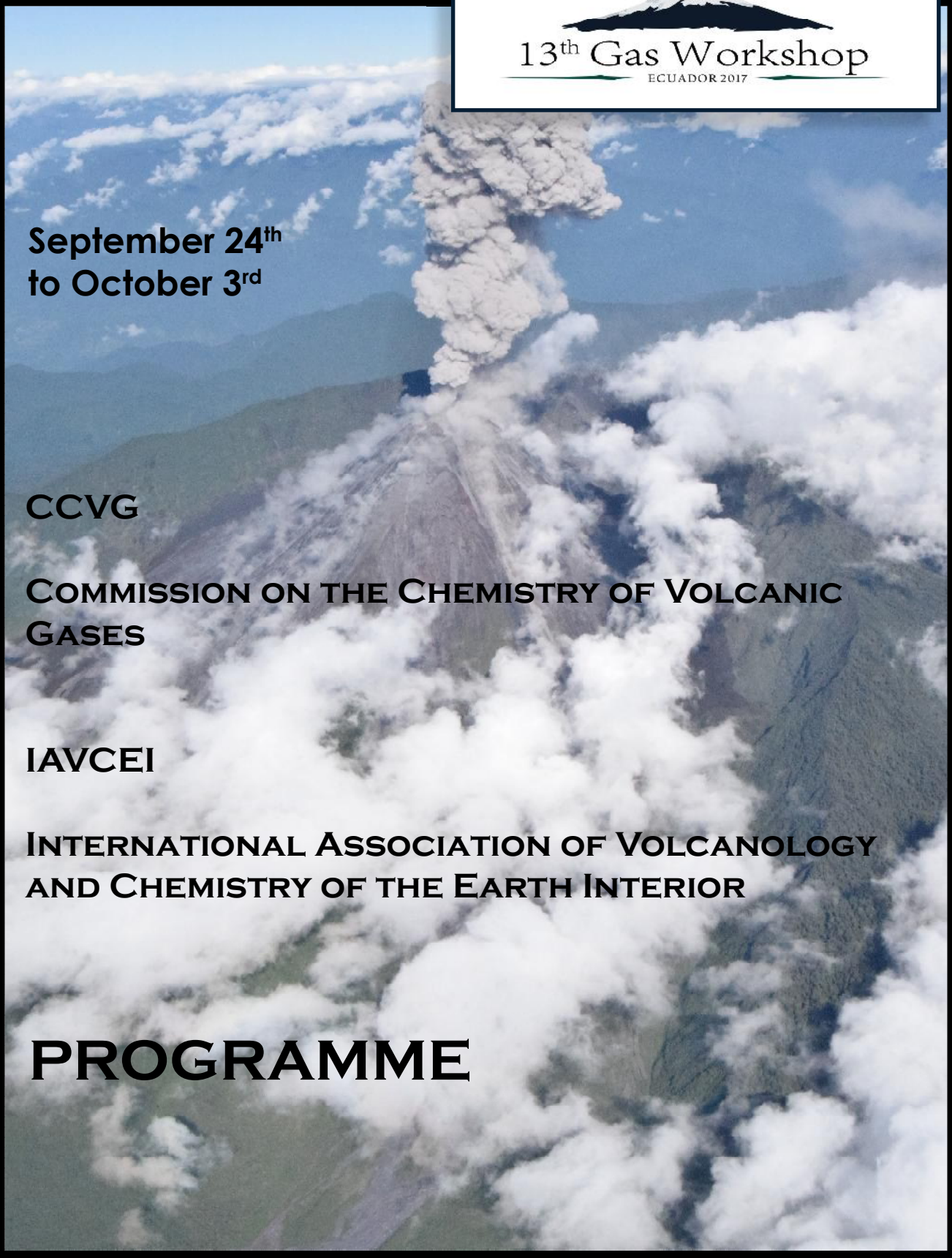
The CCVG community would like to extend heartfelt thanks to the organizers of the 13th workshop, in particular Silvana Hidalgo and the staff of the Instituto Geofísico of Escuela Politécnica Nacional, including Marco Almeida, Benjamin Bernard, Jorge Córdova, Elizabeth Gaunt, Diego Narvaez, Patricio Ramón, Daniel Sierra, Francisco Vásconez, and Freddy Vásconez for extraordinary preparations and support during the workshop. Also to Jonathan Hall from Ecuador Journeys for fantastic logistical organization of the workshop, and personalized assistance to the participants. Finally to the members of the scientific committee for preparation of the programme. This 13 Gas Workshop benefited from the financial support of the IAVCEI.

We would also like to thank the outgoing board members, Nicole Bobrowski (leader), Maarten de Moore (editor/webmaster) and Taryn Lopez (secretary) for their excellent service to the CCVG community.

Annex: Final programme of the 13th Workshop of CCVG (including optional trips) and List of Participants

13th Gas Workshop

ECUADOR 2017



September 24th
to October 3rd

CCVG

Commission on the Chemistry of Volcanic Gases

IAVCEI

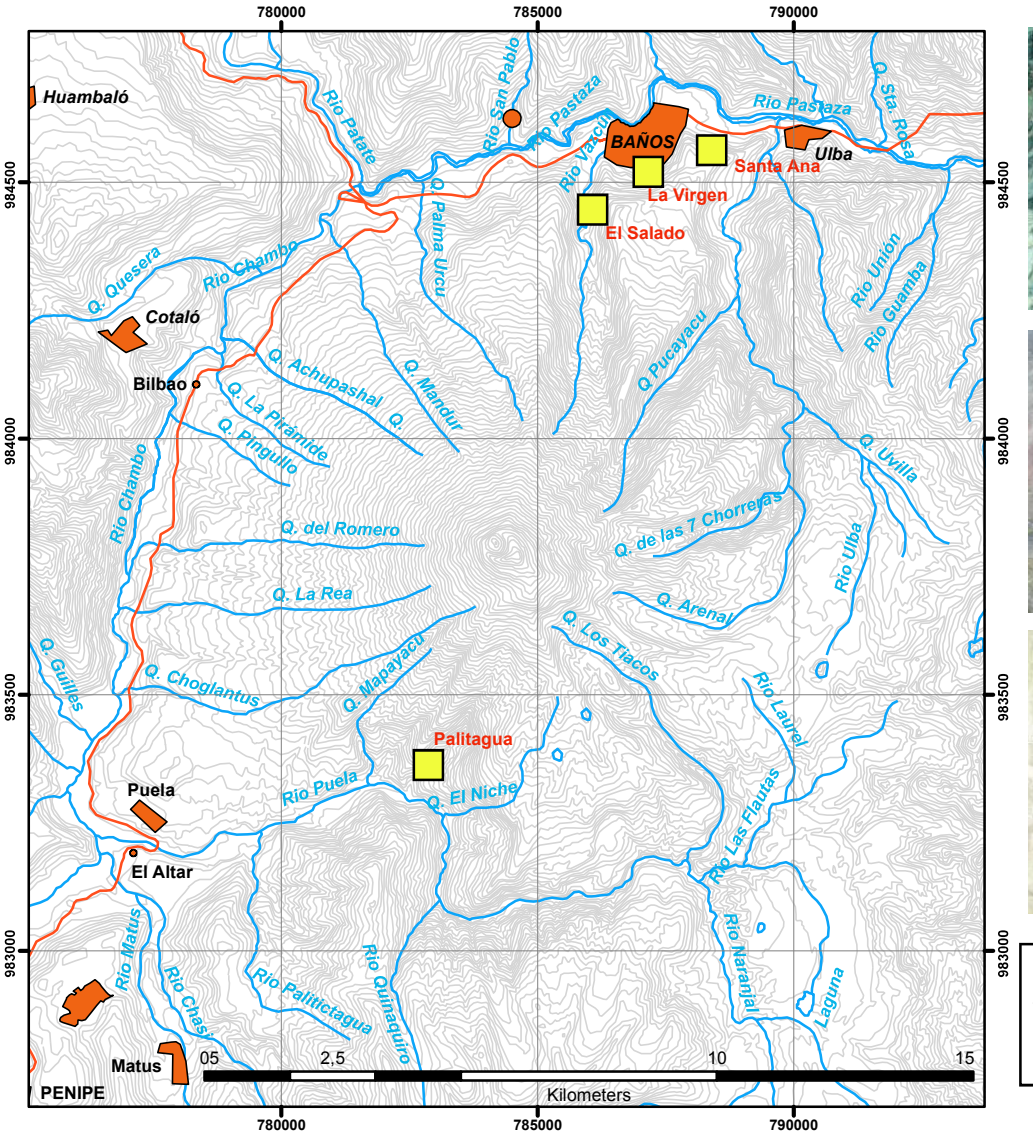
International Association of Volcanology and Chemistry of the Earth Interior

PROGRAMME

CCVG IAVCEI IG Instituto Geofísico EPN Parque Nacional GALÁPAGOS Ecuador

Thermal Springs : Thursday 28 and Friday 29 September

At Tungurahua the continuous presence of high-flow rate thermal springs at the base of the volcanic edifice and active fumaroles in the crater rim and some 1000 m bellow it, indicate the presence of a well developed hydrothermal system. **Water and bubbling gases can be sampled at three sites: La Virgen, Santa Ana and El Salado. Palitagua is another thermal spring the site is remote.**

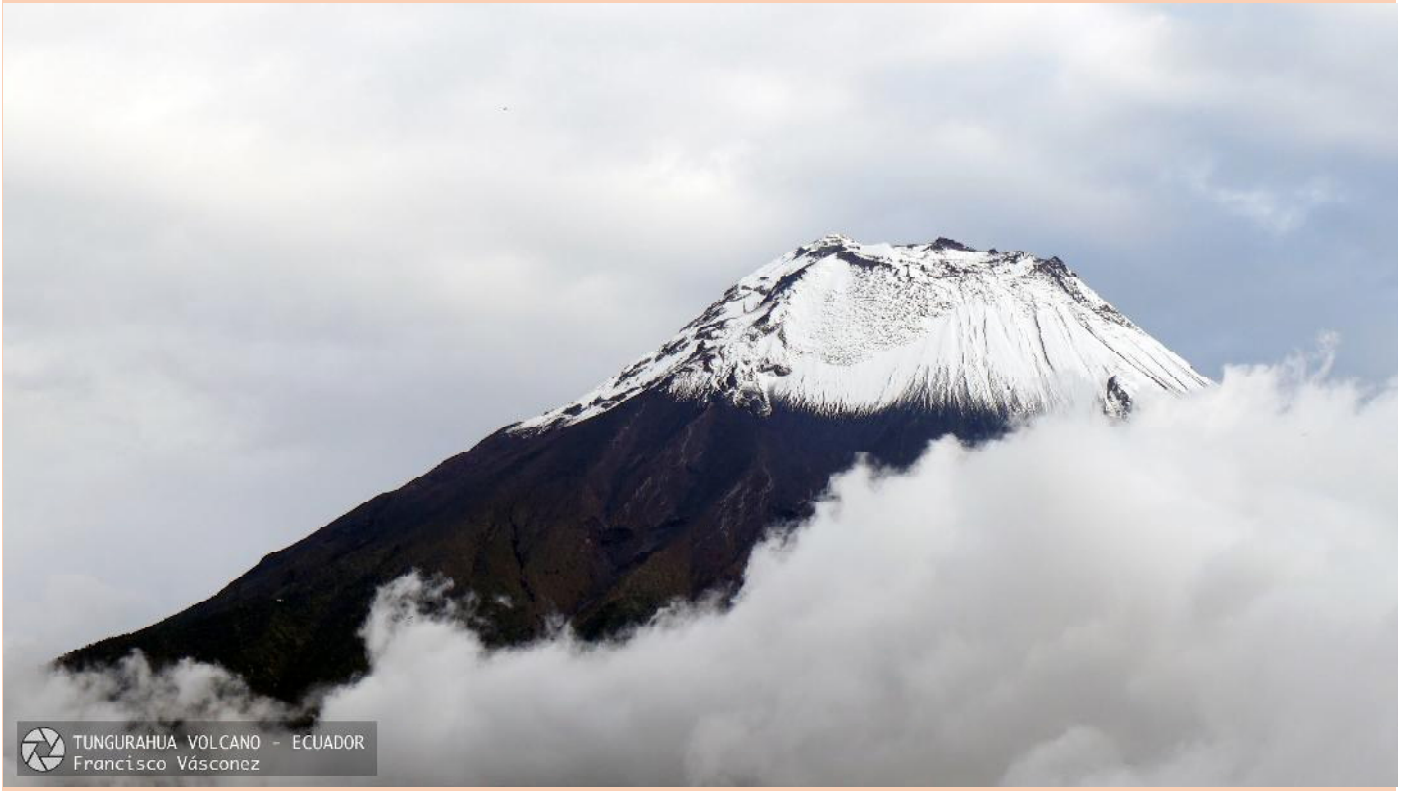


a. La Virgen
b. Santa Ana
c- El Salado

Location of the thermal springs around Tungurahua and the sources themselves.

Remote Sensing : Thursday 28 and Friday 29 September

Remote sensing, like COSPEC, MAX-DOAS, mobile-DOAS, Solar - FTIR, UV and IR cameras have been performed at Tungurahua since 1999, when it started an intense activity period. Since March 2016, gas emissions have not been detected at Tungurahua, hence this kind of measurements might not be possible during this workshop.



Tungurahua seen from the Tungurahua volcano observatory, located15 km to the NW of the volcano.

Tungurahua crater from the summit.

GUAGUA PICHINCHA VOLCANO

Cristal dome from the crater rim.
Fumaroles at the base of Cristal dome
Sunday 1st October

The currently active center of the volcanic complex, the Late Holocene Cristal dome, is nested inside the west-opening Toaza amphitheater. The last active period of Guagua Pichincha started in 1999 and finished in 2001. Activity started with phreatic explosions followed by vulcanian explosions. Afterwards, dome forming eruptions with consecutive collapses were the main observed phenomena.

Between May 2016 and June 2017 uplift was observed by INSAR. Seismic swarms occurred every one or two weeks until April 2016. Since then only few earthquakes were recorded.

There are few sampling fumaroles with temperatures around 80-90ºC. Sampling here requires accessing to the active dome 700 m below the crater rim. This will be considered the days before depending on the seismic activity.
UV and IR cameras, as well as drones can be used from the crater rim without any danger.

PULULAHUA VOLCANO

A **campain to measure CO_2 degassed through soil** is planned at Pululahua (**Sunday 1st and Monday 2nd October**) We will spend two days in order to get enough data points to make a CO_2 degassing map to ideally compare the obtained results to those published by Padrón et al. (2008).

COTOPAXI VOLCANO

Remote sensing measurements will be possible at Cotopaxi. We'll spend one day (**Monday 2nd October**) trying to make distal measurements from the Refugio parking at 4600 m a.s.l. SO_2 measured by permanent DOAS stations is around 300 t/d, it is low compared to what was emitted during the activity in 2015. Nevertheless, SO_2 is present in the plume.

Volcanic plume at Cotopaxi crater.

Pre-Conference field trip : Wednesday 20 to Saturday 23 September

REVENTADOR VOLCANO

Reventador has been erupting since 2002. On June 24, a lava flow reaching 2.6 km from the crater was emitted. Discrete explosions, sometimes with small pyroclastic flows, occur every 1-2 hours. Last measurements of SO_2 by DOAS, performed on August 2017, yielded 800 t/d. **Remote sensing, with MAX-DOAS, mobile-DOAS, Solar - FTIR, UV and IR cameras is possible**. Diffuse CO_2 might be difficult as the relief is formed by a field of lava flows extruded since 2002. Due to the explosive activity, no in-situ measurements are currently possible.

Volcanic explosions seen from the air. Plume and lava flow seen from 4.6 km from the vent.

Fumarolic field at Sierra Negra

At Galápagos we will visit the Volcán de Azufre fumarolic field in Sierra Negra volcanoe. Several fumaroles are present. The maximum temperature measured on 2014 was of 280 ºC. SO_2 flux measured in 2014 by mobile-DOAS yield 10t/d.

Here in situ sampling is possible, also remote sensing methods could be performed. CO_2 difused through soil is possible too (Padrón et al. 2012).

Pictures by: Marco Almeida, Stefany Almeida and Francisco Vásconez.

CONGRESS CCVG-IAVCEI
September 24- October 04, 2017

September 24 Sunday

13:00- 17:00 Registration of participants and distribution of congress material
*Hotel Check In starts at 13:00
16:30-18:00 Ice Breaker- Welcome cocktail and invitation by Congress hosts
18:00-20:00 Ecuadorian Party bus "Chiva" with music and drinks
Free for dinner
Lodging Hotel Reina Isabel

September 25 Monday

07:00- 09:00 Breakfast
09:00- 12:00 Travel to Baños
12:00-13:00 Check in to Hotel Sangay
13:00-14:30 Lunch at Hotel Sangay

SCIENTIFIC PROGRAM (Hotel Sangay Conference room)

14:30-14:45 Welcome by CCVG Leadership – Franco Tassi and Nicole Bobrowski
14:45-15:30 Volcanoes and Gas Monitoring in Ecuador – Silvana Hidalgo and Santiago Arellano

OBSERVATIONS AND INTERPRETATIONS I, Conveners: Nicole Bobrowski and Franco Tassi

15:30-16:00 BrO/SO2 variations in the volcanic gas plumes of Cotopaxi and Tungurahua - Florian Dinger
16:00-16:30 Sulfur dioxide degassing in Copahue Volcano between 2014 and 2016 and its relationship with surface activity – Gabriela Velasquez

16:30-17:00 Coffee Break

17:00-18:30 POSTER SESSION 1: Volcanic Gas Impacts & Observations and Interpretation (See details on Pages 5-7) Lobby and La Cascada Salon

19:00-20:00 Dinner at Hotel Sangay
Evening Free & Lodging at Hotel Sangay

September 26 Tuesday

07:30- 09:00 Breakfast

SCIENTIFIC PROGRAM (Hotel Sangay – Conference room)
TECHNICAL DEVELOPMENT, Conveners: Franco Tassi and Nicole Bobrowski

09:00-9:30 Volcanic gas studies in high altitude volcanic plumes with a compact drone – Santiago Arellano
9:30-10:00 Remote measurement of high pre-eruptive water vapor emissions at Sabancaya Volcano by passive differential optical absorption spectroscopy – Christoph Kern
10:00-10:30 Quantitative imaging of volcanic plumes – Recent advances – Ulrich Platt

10:30-11:00 Coffee Break

September 26 continued.

TECHNICAL DEVELOPMENT, Conveners: Patrick Allard and Ryunosuke Kazahaya

11:00-11:30 UV remote sensing of volcanic gases with smartphone sensor based imaging and spectroscopic devices – Thomas Wilkes
11:30-12:00 Investigation of BrO in volcanic plumes: Comparing satellite data from OMI and GOME-2 - Simon Warnach
12:00-12:30 Halogen speciation in the as and particle phase: Analytical methods and applications – Thorsten Hoffmann

12:30-14:00 Lunch at Hotel Sangay

VOLCANIC GAS IMPACTS, Conveners: Patrick Allard and Ryunosuke Kazahaya

14:00-14:30 On the CO2/St gas ratio vs. trace element association in arc magmas, and its implication for the global volcanic CO2 output – Alessandro Aiuppa
14:30-15:00 Global distribution of carbon isotopes in volcanic gases – Tobias Fischer
15:00-15:30 Updated constraints on Aleutian Arc volatile cycling through volcanic gas geochemistry – Taryn Lopez

15:30-16:00 Coffee Break

VOLCANIC GAS IMPACTS, Conveners: Santiago Arellano and Taryn Lopez

16:00-16:30 Transport of metals in the volcanic plumes of White Island, Yasur and Etna – Celine Mandon
16:30-17:00 Unseen but not unfelt: Building resilience to persistent volcanic emissions (UNRESP): A case study from Masaya Volcano, Nicaragua – Evgenia Ilynskaya

17:00-18:30 POSTER SESSION II: Technical Development & Multidisciplinary
(See details on Pages 5-7; Lobby and Salon La Cascada)

19:00-20:00 Dinner at Hotel Sangay

Evening Free & Lodging at Hotel Sangay

September 27 Wednesday

07:30- 09:00 Breakfast

SCIENTIFIC PROGRAM (Hotel Sangay – Conference room)
OBSERVATIONS & INTERPRETATIONS II: Conveners: Taryn Lopez and Santiago Arellano

09:00-09:30 Variation of volcanic gas composition and magma-hydrothermal interaction at Nakadake Crater, Aso Volcano, Japan – Hiroshi Shinohara
09:30-10:00 Temperature and gas composition of the Avachinsky volcano fumaroles (Kamchatka) in 2013-2017) – Nataliya Mailik
10:00-10:30 13C/12C of CO2-rich inclusions in mantle cumulates from Stromboli Arc Voclano (Italy) reveals the influx into the wedge of CO2 from slab sediments – Andrea Rizzo

10:30-11:00 Coffee Break

September 27 continued.

OBSERVATIONS & INTERPRETATIONS II: Conveners: Tobias Fischer and Fatima Vivieros

11:00-11:30 The curious case of fumarole "F0", White Islands: Complex interaction between magmatic, hydrothermal and meteoric components along a volcanic fumarolic conduit, and current strategies for its autonomous real-time monitoring – Bruce Christenson
11:30-12:00 Investigating the connection between sulfur degassing and the oxidation state of melt at Mount St. Helens and Augustine Volcanoes (USA) via Xanes – Allan Lerner
12:00-12:30 Recent improvements in MAGA database and DECADE web portal – Carlo Cardellini

12:30-14:00 Lunch at Hotel Sangay

MULTIDISCINPLINARY: Conveners: Fatima Vivieros and Tobias Fischer

14:00-14:30 Post-paroxysmal magma degassing at Merapi Volcano, Java (Indonesia): Continuous survey and implications – Patrick Allard
14:30-15:00 Seismo-acoustic and SO2 recordings and nature of the emitted ash during the January 2010 eruptive phase of Tungurahua Volcano (Ecuador) – Jean Battaglia
15:00-15:30 Gas emissions from Cotopaxi Volcano, Ecuador, in 2015 – Silvana Hidalgo
15:30-16:00 Pre-eruptive inflation caused by gas accumulation: Insight from detailed gas flux variation at Sakurajima Volcano, Japan – Ryunosuke Kazahaya

16:00-16:30 Coffee Break

16:30-17:30 Field trip presentation – Silvana Hidalgo and Jonathan Hall
17:30-18:30 Discussion

19:00-20:00 Dinner at Hotel Sangay
Evening Free & Lodging at Hotel Sangay

September 28 Thursday

07:30- 09:00 Breakfast
09:00-16:00 Group 1: Tungurahua: Full Day DOAS with Box Lunch
09:00-16:00 Group 2: Full Day Sampling Thermal Springs & Casa de Arbol w/ Box Lunch
Free for Dinner (on your own)

September 29 Friday

07:30- 09:00 Breakfast
09:00-16:00 Group 1: Tungurahua: Full Day DOAS with Box Lunch
09:00-16:00 Group 2: Full Day Sampling Thermal Springs & Casa de Arbol w/ Box Lunch
19:00-20:00 Dinner at Hotel Sangay

September 30 Saturday

07:30- 10:00 Breakfast
10:00-14:00 Check Out and return to Quito
Remainder of the day free
Dinner on your own
Lodging Hotel Reina Isabel

October 01 Sunday

TBD Breakfast
05:00 – 16:40 Group 1- Guagua Pichincha: Full Day Guagua Pichincha with snacks & Lunch at La Antigua (2pm)
07:30-16:30 Group 2- Pululahua: Full Day Pululahua with Box Lunch

Remainder of the day free
Dinner on your own
Lodging Hotel Reina Isabel

October 02 Monday

07:30-16:30 Group 1- Pululahua: Full Day Pululahua with Box Lunch
07:00-16:30 Group 2- Cotopaxi: Full Day Cotopaxi with Box Lunch

Remainder of the day free
Dinner on your own
Lodging Hotel Reina Isabel

October 03 Tuesday

09:00-13:00 Data analysis seminars
13:00-14:30 Free for lunch
15:30-16:30 Presentation of proposals for next workshop & discussion
16:30-17:00 Coffee Break
17:00-18:30 Final discussion time and closing remarks
20:00-21:00 Farewell Dinner at Hotel Reina Isabel
Lodging Hotel Reina Isabel

October 04 Wednesday

All Day Transfers Hotel to the Airport

POSTER SESSION I:

VOLCANIC GAS IMPACTS

1. FIRST DETERMINATION OF THE CHEMISTRY AND FLUXES OF MAGMA-DERIVED GAS EMISSIONS FROM MAYON VOLCANO, PHILLIPINES – Patrick Allard

2. HOW MUCH IODINE MONOXIDE CAN BE FOUND IN MT ETNA'S PLUME? – Nicole Bobrowski

3. DOAS-NOVAC NETWORK AT COLOMBIAN VOLCANOES (2006-2017) – Viviana Burbano

4. A DECADE OF GLOBAL VOLCANIC SO2 EMISSIONS MEASURED FROM SPACE – Simon Carn

5. PRELIMINARY ASSESSMENT OF VOLATILE CONTROL ON THE CENTRAL ANDEAN VOLCANIC ZONE, NORTHERN CHILE – Cristobal Gonzales

6. UNDERSTANDING THE ENVIRONMENTAL IMPACTS OF LARGE FISSURE ERUPTIONS: AEROSOL AND GAS EMISSIONS FROM THE 2014–2015 HOLUHRAUN ERUPTION (ICELAND) – Evgenia Ilyinskaya

OBSERVATIONS & INTERPRETATIONS

7. MONITORING DIFFUSE CO2 DEGASSING DURING THE VOLCANIC UNREST OF CAMPI FLEGREI (ITALY) – Carlo Cardellini

8. GAS EMISSIONS FROM VOLCANOES OF THE KURIL ISLAND ARC (NW PACIFIC): GEOCHEMISTRY AND FLUXES – Yuri Taran

9. DIFFUSE HELIUM EMISSION AND HEAT FLUX FROM CERRO NEGRO – Mar Alonso

10. MULTIGAS DEPLOYMENT FOR BASELINE CHARACTERIZATION OF GAS EMISSIONS ON THE SOLFATARA PLATEAU, YELLOWSTONE NATIONAL PARK, USA – Laura Clor

11. METHANE ORIGIN AT THE CIOMADUL VOLCANO: METHANE CONCENTRATION ABOVE 1% IN A VOLCANIC AREA – Artur Ionescu

12. CIOMADUL DORMANT VOLCANO (EASTERN CARPATHIANS, ROMANIA): GAS FLUX AND CONSTRAINTS ON THE ORIGIN OF GASES - Boglarka-Mercedesz Kis

13. CARBON DIOXIDE DIFFUSE EMISSIONS AT THE PLANCHÓN – PETEROA VOLCANIC COMPLEX, SOUTHERN ANDES, ARGENTINA – CHILE - Maria Clara Lamberti

14. CARBON DIOXIDE EMISSION FROM QUILOTOA VOLCANIC LAKE, ECUADOR - Gladys Melian

15. MONITORING DIFFUSE CO2 DEGASSING FOR THE VOLCANIC SURVEILLANCE OF TAAL VOLCANO, PHILIPPINES - Eleazar Padron

16. CONTINUOUS MONITORING OF SOIL DIFFUSE CO2 EFFLUX AT ASO VOLCANO, JAPAN – Masaaki Morita

17. MODELING OF CO2 DEGASSING DYNAMICS AT MAMMOTH MOUNTAIN, CALIFORNIA - Loic Peiffer

18. STABLE CARBON AND HYDROGEN ISOTOPES OF CH4 AND LIGHT HYDROCARBONS IN MAGMATIC AND HYDROTHERMAL EMISSIONS FROM VULCANO ISLAND (SOUTHERN ITALY) - Andrea Ricci

19. THE GEOTHERMAL RESOURCE IN THE GUANACASTE REGION (COSTA RICA): NEW HINTS FROM THE GEOCHEMISTRY OF NATURALLY DISCHARGING FLUIDS - Franco Tassi

20. EXPANSION OF A FUMAROLIC FIELD AT CALDEIRAS DA RIBEIRA GRANDE AREA (S. MIGUEL, AZORES) - Fatima Viveiros

21. INFLUENCE OF PRECIPITATION AND ATMOSPHERIC PRESSURE ON THE FUMAROLE TEMPERATURE AND THE GAS VELOCITY AT LASTARRIA VOLCANO, NORTHERN CHILE - Martin Zimmer

22. INDOOR RADON (222Rn) IN THE VOLCANIC ISLAND OF S. MIGUEL (AZORES) - Catarina Silva

23. SULFUR DIOXIDE EMISSIONS AND DIFFUSE CARBON DIOXIDE FLUX AT MASAYA VOLCANO FROM 2010 TO 2017 - Martha Ibarra

24. EVALUATION OF SULFUR DIOXIDE AT SABANCAYA VOLCANO BY DIFFERENTIAL OPTICAL ABSORPTION SPECTROSCOPY 2014-2017 - Fredy Apaza

POSTER SESSION II:

TECHNICAL DEVELOPMENT

25. IMPLEMENTATION OF AN AUTOMATIC DATA ACQUISITION SYSTEM TO MEASURE DISSOLVED CO2 CONCENTRATIONS IN NATURAL WATER SPRINGS - Jorge Cordova

26. CONTINUOUS FUMAROLIC GAS SAMPLING AND REAL-TIME ANALYSIS AT SOLFATARA CRATER (CAMPI FLEGREI, SOUTHERN ITALY) BY MEANS OF AN AUTOMATIC MONITORING SYSTEM - Alessandro Fedele

27. ON THE ACCURACY AND PRECISION OF MULTI-GAS MEASUREMENTS - Peter Kelly

28. INTRODUCING CCAV-GAS: THE CENTER FOR THE COMPLETE ANALYSIS OF VOLCANIC GASES - THE FIRST OF ITS KIND ON THE CENTRAL AMERICAN VOLCANIC ARC - Maarten de Moor

29. LED BASED QUARTZ ENHANCED PHOTOACOUSTIC SPECTROSCOPY: A COST EFFECTIVE SOLUTION FOR IN-SITU DETECTION OF VOLCANIC SULFUR DIOXIDE? - Alexander Engeln

30. UNDERSTANDING REACTIVE PLUME CHEMISTRY - DEVELOPMENT AND APPLICATION OF GAS DIFFUSION DENUDER SAMPLING TECHNQIUES WITH IN SITU DERIVATIZATION FOR THE DETERMINATION OF HYDROGEN HALIDES IN VOLCANIC PLUMES - Alexandra Gutmann

31. IMAGING TRACE GASES IN VOLCANIC PLUMES WITH FABRY PEROT INTERFEROMETERS - Jonas Kuhn

32. NON-DISPERSIVE UV ABSORPTION SPECTROSCOPY: A PROMISING APPROACH FOR CONTINUOUS IN-SITU DETECTION OF VOLCANIC SULFUR DIOXIDE - Jan-Lukas Tirpitz

33. IMAGING SO2 IN VOLCANIC PLUMES USING A SAGNAC INTERFEROMETER - Robert Wright

34. RETRIEVAL ADVANCES OF BrO/SO2 MOLAR RATIOS FROM NOVAC - Elsa Wilken

MULTIDISCIPLINARY

35. MINERALOGY AND GEOCHEMISTRY OF MINERAL SCALES FROM THE GEYSERS GEOTHERMAL FIELD, CALIFORNIA, USA - Mario Guzman

36. CHEMISTRY AND MINERALOGY OF FUMAROLIC DEPOSITS, CASE OF LASTARRIA AND GUALLATIRI VOLCANOES, NORTHERN CHILE - Manuel Inostroza

37. ABUNDANCES AND DISTRIBUTION OF FATTY ACIDS IN SINTERS FROM EL TATIO GEYSERS FIELD (CHILE) - Juan Sanchez

38. ANOMALOUS CHANGES OF DIFFUSE CO2 EMISSION AND SEISMIC ACTIVITY AT TEIDE VOLCANO, TENERIFE, CANARY ISLANDS - Gladys Melian

39. MULTIPARAMETERIC REMOTE SENSING INVESTIGATIONS INTO THE DEGASSING DYNAMICS OF MASAYA LAVA LAKE - Tom Pering

40. VOLCANIC ASH IRON CHEMISTRY MODIFIED BY IN-PLUME PROCESSING: INSIGHTS FROM HIGH TEMPERATURE GAS-ASH INTERACTION EXPERIMENTS - Elena Maters

41. HIGH TEMPERATURE GAS ADSORPTION AND SCAVENGING IN LARGE VOLCANIC ERUPTIONS: AN EXPERIMENTAL APPROACH - Ana Silvia Casas

42. EXPERIMENTAL INSIGHTS INTO DEGASSING OF OPEN-VENT BASALTIC VOLCANOES - Julia Woitischek

Workshop Participants

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