12th Gas Workshop
Northern Chile

17th to 25th November 2014
Invitation

On behalf of the hosting geochemical community from the Universidad de Atacama and Andean Geothermal Centre of Excellence (CEGA), we are happy to invite you to the international geochemical scientific group working on volcanic gases to participate in the 12th Gas Field Workshop to be held in Northern Chile, in 17 – 25 November 2014.

The main topics of the workshop are the intercomparison of results of the simultaneous geochemical sampling, remote sensing methods and discussions of the current theories and observations related to volcano degassing.

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Scientific Programme

The program will include a short scientific meeting focused on geochemistry of magmatic gases and fluxes through volcanoes. The main topics will be:

Conference

1. New developments in measuring/monitoring volcanic gas compositions and fluxes: fumarolic gas sampling, soil gas prospection, MultiGas plume survey, remote UV and FTIR field spectroscopy, satellite plume imaging, etc.
2. Magma degassing processes (dissolved volatiles) and modelling frameworks for interpreting the geochemistry of volcanic (magmatic) and hydrothermal fluids.
3. Volcanic CO2 emission rates and budgets (comment: in order to include the strong CCVG involvement into the DCO-DECADE international project).
4. Volcanic plumes and the atmosphere: chemical effects, environmental and human health impacts, plume transport modelling.

Field

1. Direct sampling of fluids emitted from fumaroles (Lastarria volcano), fumaroles, geysers, bubbling pools and thermal springs (El Tatio geothermal field)
2. Measurements of soil degassing (Lastarria and Lascar volcanoes and El Tatio geothermal field)
3. Plume measurements (Lastarria and Lascar volcanoes)
General Information

Chile is a long and narrow country located in the western margin of South America, has a population that reach up ~17 million inhabitants, being its capital Santiago (~7 million inhabitants). Chile is divided in 15 regions, being the Arica-Parinacota, Tarapacá, Antofagasta and Atacama regions (from north to south) which host the CAVZ.

Central Andean Volcanic Zone (CAVZ) is a ~1,700 km long volcanic chain, located in the western margin of South America, which covers southern Perú, western Bolivia, north-western Argentina and northern Chile, being the last area which hosts almost 60% of CAVZ volcanoes. CAVZ magmatism is consequence of subduction process between Nazca oceanic and South American continental plates. Chile is located in -4 time zone between April and September, while -3 during October-March period.

CAVZ present a crust thickness between 40 and 71 km, in a region that covers 700 km-long and 200 km-wide. The average altitude is 3,700 m a.s.l. and many peaks reach up altitudes over 6,000 m a.s.l. One of most notable features is the presence of giant ignimbrite deposits, covering over 30,000 km3. Its volcanism is characterized by siliceous andesitic to dacitic products, often rhyolites, and basaltic andesites compositions are subordinated. Most typical volcanic structures correspond to stratovolcanoes, domes and calderas, and sometimes cinder cones and more restricted maars. 44 active and potentially active volcanoes belong to the CAVZ, as well as more than 18 active minor centers and/or fields and at least 6 potentially active Quaternary large siliceous ignimbrite centers and/or caldera centers. 12 volcanoes along CAVZ have presented activity since 1400 AD, while 19 volcanoes have been recognized with permanent fumarolic activity, corresponding from north to south: Coropuna, Sabancaya, Misti, Ubinas, Tutupaca (Perú), Tacora (Chile-Perú), Guallatiri (Chile), Isluga (Chile-Bolivia), Uturuncu (Bolivia), Irruputuncu, Olca, Ollagüe (Chile-Bolivia), Apacheta-Aguiucho, San Pedro (Chile), Putana (Chile-Bolivia), Alitar, Lascar (Chile), Lastarria and the highest volcano in the world, Ojos del Salado (6,887 m a.s.l.) (Chile-Argentina). The anomalous geothermal gradient related to the presence of a convergent plate boundary over this large region produces diffuse hydrothermal activity not necessarily associated with the volcanic structures. This activity is represented by different geothermal fields like Salar de Surire, Puchuldiza-Tuja, Pampa Lirima, El Tatio, La Torta de Tocorpuri, Laguna Verde (Chile) and Sol de la Mañana (Bolivia). Additionally, over 100 thermal springs are present along CAVZ.

Lastarria is a composite stratovolcano located 250 km SE of Antofagasta city (northern Chile), in the Lastarria-Cordón del Azufre (Lazufre) volcanic complex in the CAVZ. Both the main summit crater and the outer flanks of the volcanic edifice have exhibited continuous fumarolic activity since its discovery at the end of nineteenth Century. Within the currently active fumarolic fields, fumarolic gases are typically emitted from: (a) fractures (~1 – 0.5 cm), (b) chimneys (15 cm high and 7 cm in diameter), and (c) cone-like (up to 2 m diameter) vents, which temperatures that ranged from 80 to 408ºC. The Lastarria system consists of four distinct fumarolic fields located in: (1) the NW external flank of the volcanic edifice along a 500 m long NW–SE trending fracture system, (2) the E border of crater IV (central crater), (3) the W border of crater IV (central crater), and (4) the bottom of crater V (northernmost crater). Interferometric Synthetic Aperture Radar (InSAR) images recorded between 1992 and 2006 indicate extensive ground deformation throughout the
Lazufre complex, since early 1998, which proceeds with a maximum inflation rate of ~2.5 cm year\(^{-1}\) affecting an area extending along a NNE-oriented elliptical area of ~45–37 km. InSAR data from 2003 to present indicates topographic inflation within an isolated 6 km\(^2\) area surrounding the Lastarria volcano that has proceeded at ~9 mm year\(^{-1}\). The geomorphologic evolution of the Lazufre volcanic complex was consequently interpreted as a signal of potentially rejuvenated volcanic activity within the area. There are no known historical eruptions of Lastarria (i.e., since the late nineteenth century).

**El Tatio** is the largest and best known among the Chilean geothermal fields. It is located in Antofagasta Region (Chile), 100 km east the town of Calama, at an altitude of 4,300 m a.s.l. It occupies the upper levels of the downfaulted block of the Tatio graben whose formation is related to the Pliocene–Quaternary extensional phase that affected the area of the Western Andes Cordillera. Thick deposits of hydrothermal mineral alteration cover the area where the thermal fluid discharges are located. El Tatio geothermal system, locally known as “Los Geiseres del Tatio”, comprises a large number of thermal manifestations (temperatures between 48.3 and 91.6°C) scattered in 4 different zones (El Tatio Central, El Tatio W, Geyser Blanco and Campamento Corfo), covering an area of about 30 km\(^2\). Feasibility studies conducted all over the Antofagasta and Tarapacá (northern Chile) provinces proved that El Tatio has to be considered one of the more promising Chilean geothermal fields. Six exploration wells were drilled between 1969 and 1971, revealing, at a depth of 600 m, temperatures up to 250°C. Seven production wells, drilled in 1973 and 1974 in the south-eastern sector and fed by 3 distinct reservoirs, were potentially able to produce about 30 MW.
**Lascar** is a composite stratovolcano located in the Antofagasta Region of Chile at about 70 km SE from San Pedro de Atacama, in the eastern fringe of the Atacama Basin. Lascar is constituted by two irregular and truncated cones (west or extinct cone and east or active cone), which hosted five nested craters aligned ENE-WSW, where the central crater is active (800 m diameter and 500 m depth). An extensive fumarolic field is present in the active crater, with the presence of fumaroles that temperatures reach up 385°C. A permanent gas plume is emitted from its active crater and constantly moved to the SE. Lascar is currently considered the most active volcano of the CAVZ. Its largest historically recorded eruption occurred on 19–20 April 1993 and produced a 25 km height Plinian column, whose collapse generated pyroclastic flows up to 8.5 km NW from the volcano summit. The resulting tephra plume expanded to SSE, covering more than 850,000 km² with, at least, 0.1 mm thick layer and reached N central Argentina, S Paraguay, Uruguay, and S Brazil. Despite the frequent small-to-medium size eruptions and the sporadic explosive events, which have attracted the international scientific community, little is known about the petrological features of the volcanic products, and only few data on the seismic activity and fluids geochemistry of the area are available. The most detailed information about the recent and present activity of Lascar volcano is from visual observations and satellite image analysis. The paucity of volcanological investigations regarding this volcano is likely due to its remote location, which makes difficult the access to the volcanic edifice. Moreover, the most important village of the region (San Pedro de Atacama) lies at more than 70 km from Lascar summit, thus only exceptionally powerful eruptions can represent a real hazard for local population.
NW (left) and SE (right) sides of Lascar volcano, with the presence of gas plume
Photographs taken by Rolando Cortés and Felipe Aguilera
Symbology

- Volcano
- Active Volcano
- Geothermal Field
- Workshop
- City / Town
- Fieldwork
- Airport
- Camp

12th Gas Field Workshop places and activities reference map
Logistics

This workshop is the result of a join organization of four different institutions: The Department of Geology of Universidad de Atacama (UDA), the Andean Geothermal Centre of Excellence (CEGA), the Advanced Mining Technology Center (AMTC) and the logistics company Campoalto Operaciones. The meetings during the workshop will be held at the Universidad de Atacama campus in Copiapó, while the fieldwork trip will be at the Lastarria volcano surroundings and El Tatio geothermal field. During these days we will need to consider some special conditions inherent to Chile’s geography: long distances between the meetings and fieldwork places and a progressive high altitude; so some considerations about timing must be taken to fully accomplish and enjoy the activity.

Proposed schedule:

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
<th>Altitude</th>
<th>Overnight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun, Nov 16th</td>
<td>Arrival day in Copiapó</td>
<td>391 m a.s.l.</td>
<td>Hotel @ Copiapó</td>
</tr>
<tr>
<td>Mon, Nov 17th</td>
<td>Registration, Opening ceremony, conferences and posters session day 1.</td>
<td>391 m a.s.l.</td>
<td>Hotel @ Copiapó</td>
</tr>
<tr>
<td>Tue, Nov 18th</td>
<td>Conferences and posters session day 2.</td>
<td>391 m a.s.l.</td>
<td>Hotel @ Copiapó</td>
</tr>
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<td>Wed, Nov 19th</td>
<td>Conferences and posters session day 3.</td>
<td>391 m a.s.l.</td>
<td>Hotel @ Copiapó</td>
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<tr>
<td>Thu, Nov 20th</td>
<td>Trip to Lastarria mine camp.</td>
<td>3.900 m a.s.l</td>
<td>Camp @ Lastarria</td>
</tr>
<tr>
<td>Fri, Nov 21st</td>
<td>Acclimatization day at Lastarria mine camp: round tables and walk trips.</td>
<td>3.900 m a.s.l</td>
<td>Camp @ Lastarria</td>
</tr>
<tr>
<td>Sat, Nov 22nd</td>
<td>Lastarria field work: Direct gas sampling and remote measurements day 1.</td>
<td>3.900 m a.s.l</td>
<td>Camp @ Lastarria</td>
</tr>
<tr>
<td>Sun, Nov 23rd</td>
<td>Lastarria field work: Direct gas sampling and remote measurements day 2.</td>
<td>3.900 m a.s.l</td>
<td>Camp @ Lastarria</td>
</tr>
<tr>
<td>Mon, Nov 24th</td>
<td>Trip from Lastarria camp to San Pedro de Atacama.</td>
<td>2.410 m a.s.l</td>
<td>Hotel @ San Pedro de Atacama</td>
</tr>
<tr>
<td>Tue, Nov 25th</td>
<td>El Tatio field work: Direct gas and water sampling.</td>
<td>4.320 m a.s.l</td>
<td>Hotel @ San Pedro de Atacama</td>
</tr>
<tr>
<td>Wed, Nov 26th</td>
<td>Departure day 1: From San Pedro de Atacama to Calama Airport and to Santiago.</td>
<td>2.410 m a.s.l</td>
<td>Hotel @ San Pedro de Atacama</td>
</tr>
<tr>
<td>Thu, Nov 27th</td>
<td>Optional field trip to Lascar volcano day 1</td>
<td>5.592 m a.s.l</td>
<td>Camp @ Atacama desert</td>
</tr>
<tr>
<td>Fri, Nov 28th</td>
<td>Optional field trip to Lascar volcano day 2</td>
<td>5.592 m a.s.l</td>
<td>Hotel @ San Pedro de Atacama</td>
</tr>
<tr>
<td>Sat, Nov 29th</td>
<td>Departure day 2: From San Pedro de Atacama to Calama Airport and to Santiago.</td>
<td>2.410 m a.s.l</td>
<td>-</td>
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</tbody>
</table>
Important

- From Nov. 20th to 24th we will have to camp at an old borate mine camp near Lastarria volcano. While the organization will take care of general areas, sleeping shelters, water and food, we need to ask the participants to bring theirs sleeping bags and pads. Restrooms in the camp will be very basic.
- We will announce the cost and availability of hotel rooms in Copiapó, San Pedro de Atacama, and equipment rental at the next circulars.
- A two day fieldwork trip, on Nov 27th and 28th, to Lascar volcano will be organized for a limited number of participants as an additional activity to the workshop, for an extra fee.
- Other post-workshop field trips, both scientific and touristic, will be organized as well. These will be announced in the following circulars too.

Costs and regulations

Campoalto Operaciones will organize everything: meeting facilities, transportation, coffee breaks, meals, hotels coordination, etc. The cost per person today has an estimated of USD$1,000, but we intend to lower it as much as possible by asking for sponsorships. The final attendee ticket cost, and maybe student grants, will be announced on February 2014.

In the next circulars will share more information including: immigration, visa requirements, admission of scientific equipment, important insights about the Chilean custom rules and estimated fees of inland flight tickets, hotels, printing and other possible expenses during the workshop.

ABOUT CAMPOALTO OPERACIONES

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Important Dates
Second circular: February 2014
Abstract deadline & early registration: April 2014
Third circular: June 2014
Fourth circular: November 2014
Workshop: November 17th to 25th, 2014

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Organizer | Auspices | Sponsor | Logistics
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