

## Etna International Training School of Geochemistry. Science meets Practice

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Also this year, the “*Etna International Training School of Geochemistry. Science meets practice*” took place at Mt. Etna, now in its fourth edition. The school was hosted in the historical Volcanological Observatory “Pizzi Deneri”, one of the most important sites of the INGV - Osservatorio Etneo for geochemical and geophysical monitoring.

Mount Etna, located in eastern Sicily, is the largest active volcano in Europe and one of the most intensely degassing volcanoes of the world [Allard et al., 1991; Gerlach, 1991]. Mt Etna emits about 1.6 % of global H<sub>2</sub>O fluxes from arc volcanism [Aiuppa et al., 2008] and 10 % of global average volcanic emission of CO<sub>2</sub> and SO<sub>2</sub> [D’Alessandro et al., 1997; Caltabiano et al., 2004; Aiuppa et al., 2008; Carn et al., 2017]. Furthermore, Gauthier and Le Cloarec, [1998] underscored that Mt. Etna is an important source of volcanic particles, having a mass flux of particle passively released from the volcano during non-eruptive period estimated between 7 to 23 tons/day [Martin et al., 2008; Calabrese et al., 2011]. In general, Etna is considered to be still under evolution and rather ‘friendly’, which, along with the above, makes it a favorable natural laboratory to study volcanic geochemistry. The Observatory Pizzi Deneri was sponsored by Haroun Tazieff, and it was built in 1978 by the CNR - International Institute of Volcanology under the direction of Prof. Letterio Villari. It is located at the base of the North-East crater (2,850 m a.s.l.), near the Valle del Leone and it was built on the rim of the Ellittico caldera. A picturesque building, consisting of two characteristics domes in front of the breath-taking panorama of the summit craters. Even though it is quite spartan as an accommodation facility, the dormitories, kitchen, seminar room and laboratory are well equipped. In other words, the Pizzi Deneri observatory is a unique place close to the top of the most active volcano of Europe. The observatory lies in a strategic location making it one of the most important sites for monitoring, research and dissemination of the scientific culture.

After six field multidisciplinary campaigns (2010-2015) organized by a group of researchers of several institutions (INGV of Palermo, Catania, Naples, Bologna; Universities of Palermo, Florence, Mainz, Heidelberg), the idea of sharing and passing on the experience to the new generation of students has materialized, and the “*Etna International Training School of Geochemistry. Science meets practice*” was born in 2016. The four editions of the school were partially funded by INGV of Palermo and Catania, European Geoscience Union (EGU), Società Geochimica Italiana (SoGel) and Associazione Naturalistica Geode.



Figure 1 Group photos of the four editions of the “*Etna International Training School of Geochemistry. Science meets Practice*”.

The conceptual idea of the school is to share scientific knowledge and experiences in the geochemical community, using local resources with a low-cost organization in order to allow as many students as possible access to the school. The “*Etna International Training School of Geochemistry. Science meets practice*” is addressed to senior graduate students, postdoctoral researchers, fellows, and newly appointed assistant professors, aiming to bring together the next generation of researchers active in studies concerning the geochemistry and the budget of volcanic gases. Introduce the participants with innovative direct sampling and remote sensing techniques. Furthermore, it gives young scientists an opportunity to experiment and evaluate new protocols and techniques to be used on volcanic fluid emissions covering a broad variety of methods. The teaching approach includes theoretical sessions (lectures), practical demonstrations and field applications, conducted by international recognized geochemists. We thank all the teachers who helped to make the school possible, among these: Tobias Fischer (University of New Mexico Albuquerque), Jens Fiebig (Institut für Geowissenschaften Goethe-Universität Frankfurt am Main), Andri Stefansson (University of Iceland, Institute of Earth Sciences), Mike Burton (University of Manchester), Nicole Bobrowski (Universität Heidelberg

Institute of Environmental Physics and Max Planck Institute for Chemistry), Alessandro Aiuppa (Università di Palermo), Franco Tassi (Università di Firenze), Walter D'Alessandro (INGV of Palermo), Fatima Viveiros (University of the Azores). Direct sampling of high-to-low temperature fumaroles, plume measurement techniques (using CO<sub>2</sub>/SO<sub>2</sub> sensors such as Multi-GAS instruments, MAX-DOAS instruments and UV SO<sub>2</sub> cameras, alkaline traps and particle filters), measurement of diffuse soil gas fluxes of endogenous gases (CO<sub>2</sub>, Hg<sup>0</sup>, CH<sub>4</sub> and light hydrocarbons), sampling of mud volcanoes, groundwaters and bubbling gases. Sampling sites include the active summit craters, eruptive fractures and peripheral areas.

The students have shown an active participation both to the lessons and the fieldworks. Most of them describe the school as formative and useful experience for their future researches. Their enthusiasm is the real engine of this school.



Figure 2 Field activities.

## References

- Aiuppa A., Giudice G., Gurrieri G., Liuzzo M., Burton M., Caltabiano T., McGonigle A.J.S., Salerno G., Shinohara H., Valenza M., (2008). *Total volatile flux from Mount Etna*. Geophysical Research Letters, Vol. 35, L24302.
- Allard P., Carbonnelle J., Dajlevic D., Le Bronec J., Morel P., Robe M.C., Maurenas J.M., Faivre-Pierret R., Martin D., Sabroux J. C., Zettwoog P., (1991). *Eruptive and diffuse emissions of CO<sub>2</sub> from Mount Etna*. Nature, vol. 351, pp. 387-391.
- Burton M.R., Sawyer G.M., Granieri D., (2013). *Deep Carbon Emissions from Volcanoes*. Reviews in Mineralogy & Geochemistry, 75, 323-354. doi: 10.2138/rmg.2013.75.11.
- Calabrese S., Aiuppa A., Allard P., Bagnato E., Bellomo S., Brusca L., D'Alessandro W., Parello F., (2011). *Atmospheric sources and sinks of volcanogenic elements in a basaltic volcano (Etna, Italy)*. Geochimica et Cosmochimica Acta, vol. 75 (23), pp. 7401-7425.
- Caltabiano T., Burton M., Giammanco S., Allard P., Bruno N., Murè F., Romano R., (2004). *Volcanic Gas Emissions from the Summit Craters and Flanks of Mt. Etna, 1987 - 2000*. In Mt. Etna: Volcano Laboratory; Bonaccorso A., Calvari S., Coltelli M., Del Negro C., Falsaperla S., Eds.; Geophysical Monograph Series; American Geophysical Union: Washington, DC, USA; vol. 143, pp. 111-128.
- Carn S.A., Fioletov V.E., McLinden C.A., Krotkov N.A. (2017). *A decade of global volcanic SO<sub>2</sub> emissions measured from space*. Sci. Rep. 7, 44095; doi: 10.1038/srep44095.
- D'Alessandro W., Giammanco S., Parello F., Valenza M., (1997). *CO<sub>2</sub> output and  $\delta^{13}\text{C}(\text{CO}_2)$  from Mount Etna as indicators of degassing of shallow asthenosphere*. Bulletin of Volcanology, vol. 58 (6), pp. 455 - 458.
- Gauthierab P.J., Le Cloarec M.F., (1998). *Variability of alkali and heavy metal fluxes released by Mt. Etna volcano, Sicily, between 1991 and 1995*. Journal of Volcanology and Geothermal Research, vol.81 (3 - 4), pp. 311-326.
- Gerlach T., (1991). *Etna's greenhouse pump*. Nature, vol. 351, pp. 352-353.
- Martin R.S., Mather T.A., Pyle D.M., Power M., Allen G., Aiuppa A., Horwell C.J., Ward E.P.W., (2008). *Composition-resolved size distributions of volcanic aerosols in the Mt. Etna plumes*. Journal of Geophysical Research, vol. 113, D17211.