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Volcanic gas emission measurements using tunable mid-infrared diode laser based spectrometers

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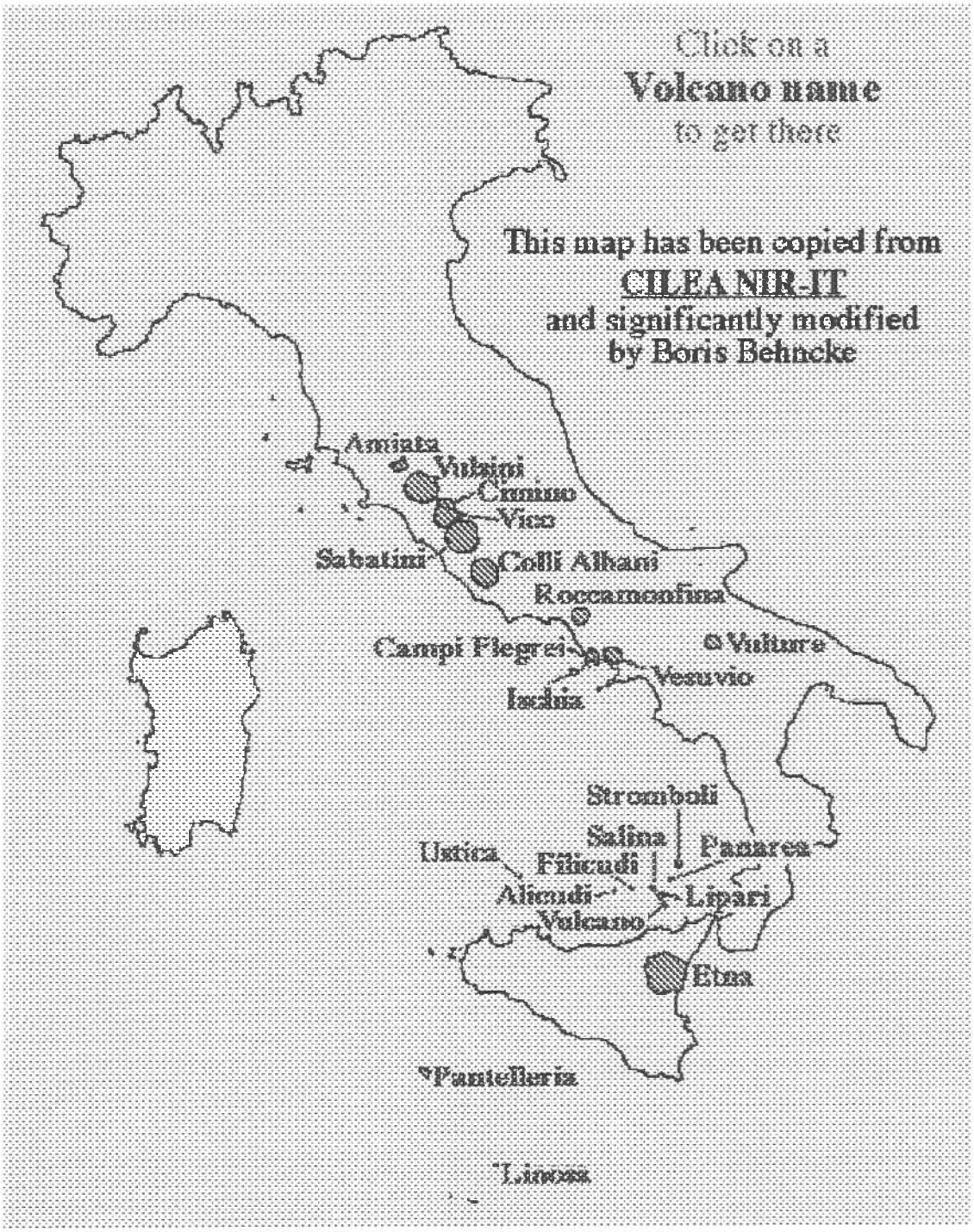
Abstract

The first field application of two mid-infrared difference frequency diode laser based sources for absorption spectroscopy of volcanic gases emitted by the Masaya volcano located in Nicaragua will be reported. Extractive gas sampling at reduced pressure using a multi pass cell was used. Simultaneous measurements were performed by open path Fourier transform spectroscopy (FTIR). The motivation for the field experiments at Masaya volcano was twofold: Firstly, to evaluate the performance of the laser based sensor technology at an active volcano site, and secondly to assess the suitability of the two spectroscopic techniques to provide information on volcanic activity such as molar and isotopic ratios and potential environmental impact to surrounding areas.. The automated, widely tunable (3.3-4.4 μm) DFG based gas sensor was operated over a four day period at the rim of the Santiago crater of Masaya volcano. Real-time (2-20 s), sensitive and selective (40 MHz) measurements of CO_2, SO_2, $H^{35,37}Cl$, H_2O, and CH_4 were made. The field portable FTIR instrument in combination with a Nernst glower, performed simultaneous open-path measurements with a spectral resolution of 15 GHz. Performance characteristics, inter-comparison of the two optical techniques and improved spectroscopic detection schemes will be discussed.

Reference:

1. D. Richter, D. G. Lancaster, F. K. Tittel, "Development of an automated diode laser based multi-component gas sensor", Applied Optics **39**, 4444-4450 (2000)

Italy's Volcanoes: The Cradle of Volcanology



Italian volcanoes presented on this site:

Amiata | Vulsini | Cimino | Vico | Sabatini | Colli Albani | Roccamonfina | Vesuvio | Campi Flegrei |

[Full page view | Italian volcanoes map | Main Index | Home Page]

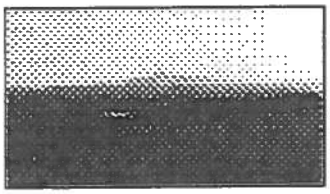
Colli Albani volcano, Italy

volcano number: 0101-004 (according to *Volcanoes of the World*, 1994 edition)

summit elevation: 949 m (Monte Cavo)

location: XXXXX°N, XXXXX°E

The following is summarized from De Rita (1993).



The Colli Albani (Alban Hills) are seen here from the southern outskirts of Roma, March 1992. Monte Cavo forms what appears to be a central cone (which, in fact, is only a high crater rim). Since the photo was taken, tens of private television antenna have been deployed on the summit (there were less than 10 in March 1992). Colli Albani most recently erupted about 22,000 years ago, forming the craters now filled by the beautiful lakes of Albano and Nemi. The area is still seismically active, as demonstrated again on 12-13 June 1995 when Roma was jolted by a series of earthquakes (up to magnitude 3.9 Richter). In fact, some are fearing a re-activation of the Colli Albani (see a June 1995 newspaper report).

Geological map of Colli Albani and surroundings, taken from De Rita et al., in Trigila (1995). Description of units:

- 1 - Travertine
- 2 - Plio-Pleistocene sedimentary units
- 3 - Colli Albani: final hydromagmatic phase products
- 4 - Colli Albani: Faete phase products
- 5 - Colli Albani: products of the Tuscolano-Artemisio phase

- 6 - lava flows
- 7 - Hydromagmatic products of the Sabatini volcanic complex
- 8 - Air-fall deposits of the Sabatini volcanic complex
- 9 - Ignimbrites of the Sabatini volcanic complex
- 10 - Tortonian flysch (pelitic-sandy facies)
- 11 - Meso-Cenozoic pelagic carbonate units (Sabina facies)
- 12 - Meso-Cenozoic carbonate platform units (Latium-Abruzzi facies)
- 13 - Caldera rims
- 14 - Crater rims:
  - a) Ariccia
  - b) Nemi
  - c) Albano
  - d) Giuturna
  - e) Valle Marciana
  - f) Pantano Secco
  - g) Prata Porci
  - h) Castiglione.

The Colli Albani, also known as the "Vulcano Laziale" or the Alban Hills volcano, form a prominent feature on the southern skyline of Roma. The structure of this somma type volcano (caldera with a central cone) is much more complex than it seems from a distance. Indeed, the volcano has two nested calderas and several eccentrical post-caldera vents.

The highest point of Colli Albani is Monte Cavo (949 m), a scoria cone sitting eccentrically on the SW rim of the younger Faete caldera. There are two crater lakes, Albano and Nemi which fill the most recent craters of the volcano. Lago Albano, with its lake level at 293 m elevation, is 170 m deep and thus the deepest of all volcanic lakes in the Central Italian volcanic region (also known as the Roman Comagmatic region). Lago di Nemi lies somewhat higher (lake level at 316 m) but is very shallow.

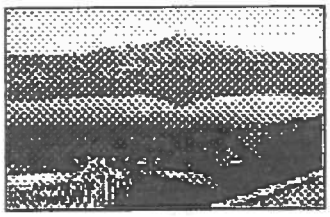
The geological evolution of the Colli Albani is generally subdivided into three major phases: 1) Tuscolano-Artemisio, 2) Faete, and 3) the final hydromagmatic phase.
The Tuscolano-Artemisio phase covers the period from 600 ka until 360 ka when almost all volcanic activity occurred from a central volcanic edifice that is named Tuscolano Artemisio as well. This phase is comprised by four eruptive cycles each of which is representated by the emplacement of pyroclastic flows and air fall tephra followed by lava flows in the closing stages of each cycle. During the first cycle, at least three large pyroclastic flows were erupted in rapid succession, followed by an effusive phase concentrated mainly in the SW sector of the volcano. This cycle lasted from about 600 until 500 ka and correlates strikingly with an eustatic lowering of the sea level.
The second cycle brought about the most significant eruption of the Colli Albani which led to the deposition of a major ignimbrite which has thicknesses of 90 m in paleovalleys exposed in the E sector of the volcano. De Rita et al. (1988) have calculated the minimum volume of this ignimbrite at about 389 km^3. Outcrops exist up to 80 km from the eruption center where there is evidence that the pyroclastic flows climbed up to about 400 m elevation on the slopes of the Monti Tiburtini, that is, about 200 m above the valley floor. This unit is named "Pozzolane Rosse" or "Pozzolane di San Paolo".
The second cycle ended with a noteworthy effusive activity, dated at about 480 ka, which again correlates with a lowering of the sea level.
The third cycle includes another significant ignimbrite eruption of similar dimensions of the preceding one; much of the volume of the corresponding ignimbrite has been removed by erosion since there was no protecting cap of succeeding lava flows.
The fourth cycle, dated at about 360 ka, is again characterized by the emission of an ignimbrite with two distinct flow units known as the "Tufo litoide" and the Villa Senni Tuff. With this major eruptive episode, the Tuscolano-Artemisio edifice of the volcano was affected by a major caldera collapse along

regional tectonic fractures. Caldera collapse was accompanied by vigorous eruptions of pyroclastics and subordinate lava flows.

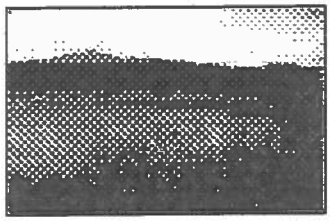
After a brief period of volcanic quiescence, activity resumed in the central area of the caldera where a new small stratovolcano was constructed (Campi di Annibale or Faete phase). This phase is also subdivided into cycles, but the significance of the eruptions and erupted volumes were much less than during the Tuscolano-Artemisio phase. The total volume of erupted products of the Faete phase is only 2 km^3, compared to about 200 km^3 of the Tuscolano-Artemisio volcanics. The Campi di Annibale-Faete phase lasted from 300 to about 200 ka.

The most recent activity of the Colli Albani is named the final hydromagmatic phase by recent reseachers. During this phase, hydromagmatic eruptions occurred from several eccentric craters, mostly in the NW and SW sectors of the volcanic complex. During this activity, the craters of Nemi and Albano as well as several less-known depressions were formed. The latest activity occurred about 20 ka ago. Historical documents mentioning eruptive activity at Colli Albani are not considered trustworthy by many recent researchers.

Until very recently, the Colli Albani has generally been considered an inactive volcano (especially after records of activity in historical sources have been discarded by various researchers, such as Stothers & Rampino 1983). However, new absolute age datings have revealed that volcanic activity occurred as recently as about 22 ka ago which is much younger than any of the other volcanoes of Central Italy. Furthermore, the volcano is seismically active, with several notable earthquake swarms since the early 1980's. And it was only in 1995 that a significant amout of very recent ground uplift was detected (Amato et al. 1995), having its maximum precisely in the central area of the volcanic complex.



View from Castelgandolfo (the famous residence town of the pope) over Lago Albano, the more northwesterly of the two crater lakes. This crater has been the vent of the most recent activity that emplaced pyroclastic surges around the crater. Monte Cavo (949 m) forms the skyline in the background. Taken on 27 December 1994, view is to the E.



Less known but more suggestive, Lago di Nemi is the smaller and shallower of the two crater lakes in the Colli Albani. The picturesque town of Nemi lies on the N rim of the crater, offering a commanding view of the lake. This view, taken on 27 December 1994, is from the W side of the crater, looking E.