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Gas geochemical survey of long dormant Ciomadul volcano (South Harghita Mts., Romania): constraints on the flux and origin of fluids

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The Ciomadul, located in the South Harghita Mountains (Eastern Carpathians, Romania) is the youngest volcano built by the Neogene volcanism in the Carpathian-Pannonian Region. The volcanic activity was characterized by an initial extrusive lava dome building period from about 200 ka to 100 ka followed by a more explosive eruption stage from 57 to 32 ka. Although the volcano seems to be inactive, several features (e.g. geophysical anomalies in the crust; fast remobilization of near solidus long lasting crystal mush prior to the past eruptions) suggest that melt-bearing magmatic body could still exist beneath the Ciomadul. This is supported by the abundance of dry gas emanations (CO_2, CH4, H2S), CO_2 rich mineral water springs and bubbling pools.
The long-term observation of seemingly inactive, dormant volcanoes has become important in the past years (Ontake volcano-Japan, Colli Albani volcano-Italy). Gas-geochemical survey and monitoring (noble gases, isotopic composition of carbon species, flux measurements) of such volcanoes is an adequate tool in detecting changes in their volcanic plumbing system.
Starting from 2015 we commenced a gas-monitoring study to constrain the origin of fluids at Ciomadul by measuring the flux of two gas-species and collecting the gas-phase from several mofettes and mineral water springs.
A total of 46 sites have been surveyed, including 29 gas emanations (mofettes and bubbling pools), 3 drilled wells, 11 springs and 3 surface water sites.
We provide the first complex CO_2 and CH4 flux measurements in the area considering mofettes and bubbling pools. The CO_2 flux values range between 10 and 264 kg/day while the CH4 flux has a range between 125 and 4723 g/day. Estimates of total CO_2 and CH4 output into the atmosphere are $\sim$229 and $\sim$1.3 t/year, respectively. These values are consistent with other geothermal systems in Europe.
The chemical composition of samples indicate CO_2 content of up to 96.77%, CH4 content up to 1.42% and He content up to 13.2 ppm.
The isotopic composition of He ranges between 2.86-1.13Ra (air-normalized 3He/4He); and δ13C CO_2 ranges between -3.24‰ and -3.59‰ vs. PDB, coherently indicating the magmatic origin of these fluids. The δ13C CH4 ranges between -23.7 and -7.8 ‰ vs. PDB, suggesting a dominant abiotic origin of CH4, variably mixed with a thermogenic (biotic) component, likely from thermal cracking of organic matter in sediments involved in the volcanic plumbing system. Pure abiotic CH4 is not quantifiable based on the currently available data. A few samples, with positive δ13C CH4 values, may suggest CH4 oxidation, probably due to local conditions.
The magmatic origin of He and CO_2 and the dual origin of CH4 (abiotic and biotic mixture) confirms the presence of a slowly degassing, melt-bearing magmatic body, consistent with previous geophysical data.

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