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A theoretical model and the experimental results for the concentration transients of CO_2, H_2, and He in the volcanic gases

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The thorough understanding of the gas transport in porous media is of considerable interest in several environmental issues, such as the transport of contaminants, nutrient substances or moisture, and to applications in subsurface repository of nuclear wastes. In volcanology, the gas transport process affects the compositions of both the soils and the fumaroles gases, that are the proxy of the magmatic activity.

Herein we study the transients of the chemical composition of the soil and fumaroles gases through the formulation of a theoretical model, and the gas flux experiments carried out in the laboratory. The theoretical model accounts for the gas releases in volcanic areas, and investigates the effects of the gas flux processes, the transport parameters in the soils, and the depth of the gas reservoir on the composition of the gas emissions. The model takes into account the process of the mass transfer triggered by the changes of the flux parameters in the system, and describes the time-dependent evolution of the composition of the soil gases as the result of the pristine gas mixture, the diffusivity of the chemicals, and the thickness of the medium. The approximate solution of the flux problem provides the retention time of the i^{th} component of the gas mixture in the porous medium as function of the thickness of the soil, the advective flux rate, and the diffusivity of the chemicals.

Carbon dioxide (CO_2), hydrogen (H_2), and helium (He) were used in a laboratory-scaled flux simulator with the purpose of investigating the evolution of the composition profile in a porous medium of constant thickness.

The comparison of the theoretical computations with the experimental results provides the evaluation of the compositional range of validity of the model. Furthermore, the results of this study indicate that the measurement of both the delays between the transients in the concentration of different components, and the gas flux provides an evaluation of the depth of the gas reservoir, because of the retention time in the porous medium is a diffusivity-dependent property, and also depends from the depth of the gas source.