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Dissolved carbon in groundwater versus gas emissions from the soil: the two sides of the same coin

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Abstract

This study focuses on the interaction among deep volcanic/hydrothermal gases, groundwater and soil gases at Vulcano Island (Aeolian Archipelago, Italy). The chemical-physical parameters of the groundwater, the total dissolved inorganic carbon (TDIC) and the isotopic composition of the CO_2 dissolved in groundwater are reported and discussed. Furthermore, a comparison between soil gases and groundwater indicates that groundwater and soil gases show the same qualitative information, giving a good overall picture of the main degassing zones of a volcanic system, whereas the soil gas discharge provides an evaluation of the mass released by the deep feeding system. This approach can be a useful tool both to characterize mixing and/or interaction processes among different sources and for a monitoring of degassing activity of a volcanic system.

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Keywords: Soil CO_2 flux; Dissolved gases; Isotope composition of CO_2; Groundwaters; Vulcano Island

1. Introduction

Water–gas interaction is an ordinary process occurring in volcanic areas because of gases released from magmatic reservoir at depth interact and dissolve in groundwater and/or are discharged from the soils or fumaroles. At Vulcano Island (Aeolian Archipelago, Sicily, Italy), the thermal and geochemical anomalies observed in the groundwater were related to structural weakness in the volcanic edifice behaving as preferential pathways for upflow of both heat and fluids discharged by the deep magmatic system[1,2]. Groundwater of Vulcano Porto area have been targeted by several studies. However, the extensive investigation on the gas-water interactions and the mass and composition of gas discharged by soils is still poorly investigated. In this study, the comparison of contents and $\delta^{13}C$ of carbon dissolved in groundwater with CO_2 flux and $\delta^{13}C_{(CO2)}$ from soil has been aimed to a more accurate definition of the

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interactions among volcanic/hydrothermal gases, the thermal groundwater and air/biogenic component in the Vulcano Porto area.

2. Studied area and methods

Among the Aeolian islands, Vulcano is the closest to the northern coast of Sicily, elongated side by side to the NNW–SSE of the Tindari-Letojanni fault system. Fumarole activity at both the northwestern rim of the La Fossa crater cone and Levante beach as well as evidence of thermal waters and high level of diffuse emissions of CO_2 from soils featured the activity of Vulcano after the end of the 1888–1890 eruption. Since then, potential reactivations of the volcanic activity have been trucked by investigating geochemical anomalies in the chemical–physical parameters of the crater fumaroles, in the chemistry and isotopic compositions of the groundwater and in the amount of gases discharged by soils.

An extensive investigation has been performed at Vulcano in May 2015 aimed to collect both water samples of the thermal groundwater and the soil gases (Fig. 1). The water sampling grid consists of seventeen wells selected in the area of Vulcano Porto (Fig.1a). Temperature, pH, and electrical conductivity of water were measured in the field as well as the amount of carbonate species. The water temperature was in the range 20 - 58.8°C, pH was in the range 5.6 - 8.0 pH units and electrical conductivity was in the range 0.1 - 21 mS/cm. For each well, a water sample was collected in 50cc glass flasks to measure the isotope composition of total dissolved inorganic carbon ($\delta^{13}C_{TDIC}$) according to[3].

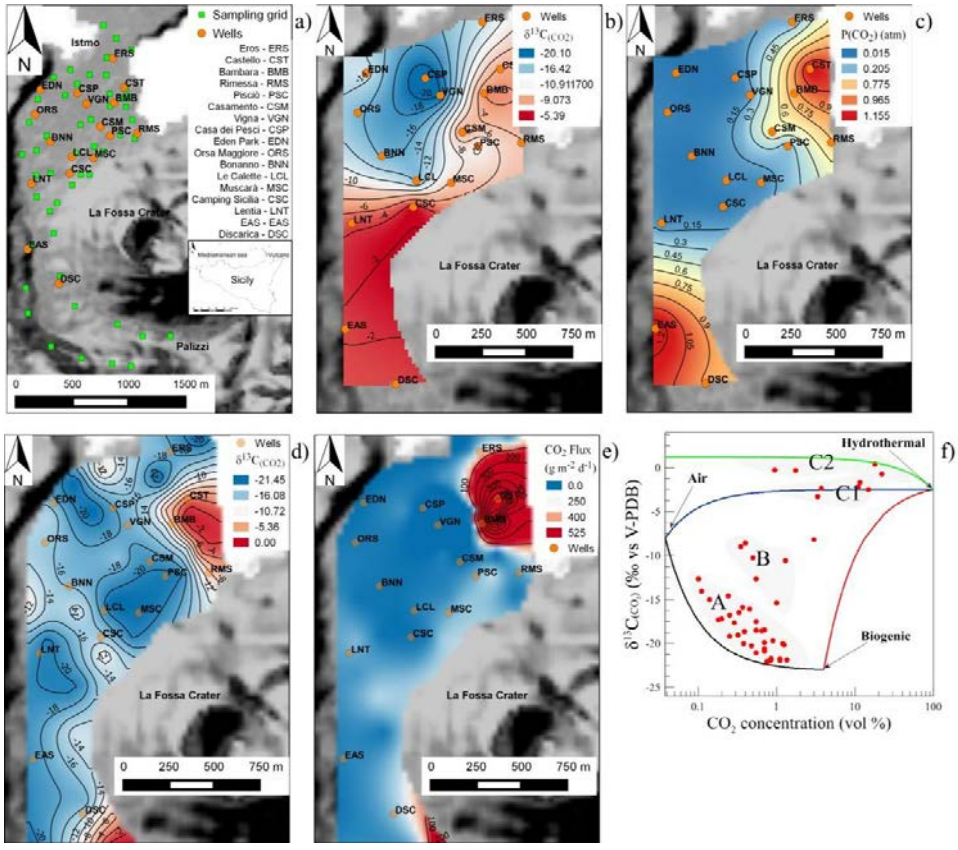

Fig.1. Vulcano Porto area. a) Water wells (orange circle) and soil gas sampling point (green square); Contour map of: $\delta^{13}C_{(CO2)}$ retrieved from $\delta^{13}C_{(TDIC)}$ (Total Dissolved Inorganic Carbon) (b); partial pressure of CO_2 dissolved in groundwater (c); $\delta^{13}C_{(CO_2)}$ in soil gases (d); and CO_2 flux from soils (e). Plot of $\delta^{13}C_{(CO2)}$ vs CO_2 concentration from soils (f). All $\delta^{13}C$ data are expressed in ‰ vs V-PDB.