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Total CO_2 flux from the Latera caldera and how flux rates affect the transfer of other reactive gas species to the atmosphere: the results of highly detailed surveys on and across individual gas vents.

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The Latera caldera, located in west-central Italy, is a large, elliptical (10x8 km), NNE-SSW trending structure with several eruptive vents. The caldera, together with Lake Bolsena, forms the Vulsini Mountains region and is part of the larger alkali-potassic Roman Comagmatic Province. Although studied since the early 1970s for geothermal energy, the area was well known long before that for the numerous CO_2-rich gas vents which are distributed throughout the internal plain of the caldera. In this area the stratigraphy consists of a thin layer of surface alluvium, volcanic units related to the caldera, "Ligurian" flysch units, "Tuscan" limestone units, and then metamorphic basement. Thermo-metamorphic reactions within the Tuscan limestones, related to high heat flow and the intrusion of a hot Na-Cl brine, are thought to form the CO_2 and associated trace gases, while the migration of these gases to surface likely occurs along isolated, high-permeability pathways within faults or at the intersection of faults.

The present work summarises some of the results obtained over the last 5 years within the EC-funded "Nascent" project and "CO2GeoNet" Network of Excellence, both of which used the leaking CO_2 reservoir at Latera to better understand gas migration, to study the effect of the unsaturated zone on gas species transfer to the atmosphere, and to test various near-surface techniques in terms of their response to leaking deep gas. During this work a total of more than 20 individual gas vents were located and studied, although three were studied in much more detail. Although many techniques have been applied, only soil gas and gas flux results will be presented here. Soil gas surveys consisted of sampling with a hollow stainless-steel tube at a depth of approximately 80cm for field analysis of CO_2, H_2, and H_2S, and for laboratory analysis of CO_2, N_2,

O_y+Ar (or O_y and Ar in some cases), helium, methane, ethylene, acetylene, ethane and propane. Soil gas surveys consisted of highly detailed (every metre) and detailed (every 2 to 4 metres) horizontal profiles across individual or multiple vents, as well as local and regional grids. Gas flux measurements consisted primarily of CO_2 flux measurements, however a limited number of H_2S, H_2 and CH_4 flux measurements have also been made. The CO_2 flux measurements were often conducted along the soil gas horizontal profiles, while separate detailed grids were also performed to calculate total CO_2 flux from individual vents.

Detailed profiles across individual vents highlighted the zoned nature of these features as well as the variable behaviour of different gas species. For example in one profile where both soil gas and CO_2 flux measurements were conducted, a central core of high gas flux rates was found which also contained elevated CH_4 (and other hydrocarbon gases), H_2S and H_2 soil gas concentrations. Outside this core flux values dropped off rapidly and the concentrations of the reactive species quickly returned to background values. On a longer profile which crossed a number of different vents it was observed that CO_2 and He were present at anomalously high concentrations in each vent, however CH_4 and H_2S were only present, together, in very few points, again highlighting that these reactive gases can be transferred to the atmosphere only under high flux regimes. This is also seen in the limited number of H_2S, H_2 and CH_4 flux measurements made on some vents. Instead CO_2 flux measurements conducted on detailed grids (5 or 10 m sample spacing) and profiles on individual vents allowed for an estimate of the transfer of CO_2 from each vent. The sum of these individual values represents a preliminary estimate of the total CO_2 emitted to the atmosphere from the Latera geothermal field; this value is a similar order of magnitude compared to other estimates made using different techniques. To understand these results in terms of global CO_2 inputs, these results are compared with anthropogenic sources (e.g. coal fired power plants).