The degassing character of an explosive basaltic volcano: Cerro Negro, Nicaragua

G. LUCIC[1], J. STIX[1], B. SHERWOOD LOLLAR[2], G. LACRAMPE-COULOUME[2], A. MUÑOZ[3] AND M. I. CARACHE[3]

[1]Dept. of Earth and Planetary Sciences, McGill University, 3450 University Street, Montreal, QC, H3A 0E8, Canada
[2]Dept. of Earth Sciences, University of Toronto, 22 Russell Street, Toronto, ON, M5S 3B1, Canada
[3]Instituto Nicaragüense de Estudios Territoriales (INETER), Frente a Hospital Solidaridad, Apdo. Postal 2110 Managua, Nicaragua

We present a comprehensive degassing characterization of Cerro Negro volcano over a 4-year period aimed at improving our understanding of the magmatic plumbing network and its relationship with regional tectonics. Soil gas samples were collected and analyzed for $\delta^{13}C$ from CO_2 gas, high-temperature fumaroles were sampled for $\delta^{18}O$, $\delta^{2}H$ and $^{3}He/^{4}He$, and hydrothermal zones were mapped using soil CO_2 flux measurements. Present day degassing is controlled by a zone of regional north-south striking extension capable of tapping deep pockets of magma and gas in the lower crust. Near-surface faults and fractures produce elongate and well-defined surface expressions of hydrothermal activity from which occur prominent CO_2 emissions with sizable contributions from zones of diffuse degassing. These structural features are sensitive to changes in the local stress regime, which is capable of opening and closing conduits of gas ascent as well as inducing eruptions. Increased groundwater flow during periods of high rainfall may exploit these fractures, supplying a large proportion of meteoric water to the hydrothermal system, resulting in lighter $\delta^{13}C$ ratios. CO_2-He systematics at Cerro Negro indicate a strong and constant mantle signature of 6.3 to 7.3 R_A ($^{3}He/^{4}He$), with a heavier than average $\delta^{13}C$ of ~ -3.5‰ (as heavy as -0.75‰) due to melting of marine carbonates from the subducted Cocos plate. The lack of long-term changes in $\delta^{13}C$ suggests the plumbing system of Cerro Negro acts as a "laser beam" to the lower crust, supplied by a constant flux of upper mantle volatiles. Despite the lack of new eruptions, the hydrothermal system of Cerro Negro continues to evolve due to seasonal inputs of meteoric water, slope failures that expose and bury sites of active degassing, and bursts of regional seismicity that have the potential to temporarily increase permeability. These processes demonstrate that a multi-component, multi-seasonal study of soil and fumarole gases is necessary to accurately define the isotopic degassing character of a volcanic center.