TEN YEARS OF DEGASSING AT MASAYA VOLCANO, NICARAGUA : WHAT HAVE WE LEARNED ?

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In mid-1993, appearance of an ephemeral lava lake accompanied by emission of a persistent gas plume indicated reactivation of Masaya volcano, a large basaltic shield edifice in central Nicaragua. Almost 13 years later, the gas crisis continues with average SO_2 emission rates of ~800 Mg/day and persistent incandescence of the degassing pit vent. Historical accounts reveal that several episodes of intense gas emissions have occurred at Masaya since the time of the Spanish Conquistadors. The ongoing gas crisis has provided an unprecedented stream of geophysical, geochemical and environmental data, acquired on a more or less regularly basis for the last 10 years. These have given new insights into magma degassing processes, plume chemistry and environmental impacts at Masaya volcano.

Integration of micro-gravity and gas flux measurements reveals a pattern of repeated fluctuations, which cannot be explained by intrusion of new magma batches at shallow depths. Rather, it has been surmised that a gas-rich vesiculated zone forms and oscillates near the surface immediately beneath the active crater. In parallel with conventional plume sampling techniques, Fourier Transform InfraRed (FTIR) spectroscopy has been intensively used to monitor Masaya's plume. A striking result is that in terms of SO_2, HCl and HF, the Masaya gas composition has been relatively stable since 1998, suggesting an open-degassing system with deep release of volatiles from the magma. In contrast to the major gas species, recent time-series data on radioactive disequilibria in the gas plume of Masaya indicate significant variations. The working hypothesis is that input of deep pristine magma in a large magma reservoir controls the gas flux at the surface. Soil diffuse degassing also occurs on the flanks of Masaya. Fluxes of CO_2 (with a deep origin) are among the highest reported for volcanoes worldwide.

The plume of Masaya has also been measured for the near-source chemistry of its particulate phase. This work has highlighted the presence of "primary" sulphate aerosols that may have been formed by SO_2 oxidation at high temperature. Another interesting discovery is linked to the possibility that the hot vent allows thermal fixation of atmospheric N_2 and concomitant formation of NO, NO_2 and HNO_3. In addition to the near-source studies, a few experiments have been carried out with the aim of understanding how the plume chemistry evolves during transport in the atmospheric boundary layer. Apparently, there is little variation in the ratios of the plume components between the crater rim and 15 km downwind, suggesting that, over this length scale, atmospheric processes do not affect the plume composition significantly.

Atmospheric dispersion of the low-altitude gas plume of Masaya results in profound environmental and agricultural impacts downwind. These include SO_2 concentration levels well above background values, and moderate to extensive damage to vegetation in areas directly exposed to the volcanic emissions. Large deposition fluxes of acidic species (SO_2, HCl and HF) affect a 22-km^2 area south-west of the volcano, and concerns have been raised over the possibility of soil acidification. Laboratory and field experiments involving the volcanic ash soils found in this area demonstrate the strong capacity of the soils to buffer acid inputs. However, continuous deposition of volcanic acids has led to spectacular accumulation of fluoride in the soils. It is anticipated that both short- and long-term negative health effects occur as a result of chronic exposure of people to Masaya's gases and particles. High level of fluoride in soils also may pose a risk to grazing animals.