

## **Gas flushing through hyper-acidic crater lakes: the next steps within a reframed monitoring time window**

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Tracking variations in the chemical composition, water temperature and pH of brines from peak-activity crater lakes is the most obvious way to forecast phreatic activity. Volcano monitoring intrinsically implies a time window of observation that should be synchronised with the kinetics of magmatic processes, such as degassing and magma intrusion. To decipher “how much time ago” a variation in degassing regime actually occurred before eventually being detected in a crater lake is key, and depends on the lake water residence time. The above reasoning assumes that gas is preserved as anions in the lake water (SO<sub>4</sub>, Cl, F anions), in other words, that scrubbing of acid gases is complete and irreversible. Less is true. Recent work has confirmed, by direct MultiGas measurement from evaporative plumes, that even the strongest acid in liquid medium (i.e. SO<sub>2</sub>) degasses from hyper-acidic crater lakes. The less strong acid HCl has long been recognised as being more volatile than hydrophyle in extremely acidic solutions (pH near 0), through a long-term steady increase in SO<sub>4</sub>/Cl ratios in the vigorously evaporating crater lake of Poás volcano. We now know that acidic gases flush through hyper-acidic crater lake brines, but we don’t know to which extent (completely or partially?), and with which speed. The chemical composition hence only reflects a transient phase of the gas flushing through the lake. In terms of volcanic surveillance this brings the advantage that the monitoring time window is definitely shorter than defined by the water chemistry, but yet, we do not know how much shorter. Empirical experiments by Capaccioni et al. (in press) have tried to tackle this kinetic problem for HCl degassing from a “lab-lake” on the short-term (2 days). With this state of the art in mind, two new monitoring strategies can be proposed to seek for precursory signals of phreatic eruptions from crater lakes: (1) Tracking variations in gas compositions, fluxes and ratios between species in evaporative degassing plumes can be useful as monitoring tool on the short-term, but only if the underlying process of gas flushing through acidic lakes is better understood, and linked with the lake water chemistry; (2) The second method forgets about chemical kinetics, degassing models and dynamics of phreatic eruptions, and sticks to the classical principle in geology of “the past is the key for the future”. How did lake chemistry parameters vary during the various stages of unrest and eruption, on a purely mathematical basis? Can we recognise patterns in the numerical values related to the changes in volcanic activity?

Water chemistry only as a monitoring tool for extremely dynamic and erupting crater lake systems, is inefficient in revealing short-term precursors for single phreatic eruptions, within the current perspective of the residence time dependent monitoring time window. The monitoring rules established since decades based only on water chemistry have thus somehow become obsolete and need revision.