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Connections between hyper-acid crater lakes and flank springs: new evidence from Rincón de la Vieja volcano (Costa Rica)

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Rincón de la Vieja, a complex andesitic stratovolcano in NW Costa Rica, shows various hydrothermal surface manifestations that comprise: (1) A hyper-acid crater lake and subaerial fumaroles receiving direct input of fluids of magmatic origin, (2) Acid thermal discharges along the northeastern slopes of the volcano that feed the headwaters of the Cucaracho river, and (3) Small lakes and a geothermal field with bubbling-boiling mud pools, acid-sulfate springs, steaming ground and fumarolic emissions in a region on the western flank. Here the streams are of relatively low flow rate and their chemical signatures correspond to that of deep fluids from an extensive geothermal reservoir mixed with shallow meteoric water.

Physico-chemical properties of the sulfate-chloride hyper-acid lake (T=28-58 °C; pH between 1.2 and <0, high TDS of 24,000-160,000 mg/kg) are consistent with a meteoric water body supplied by a significant input of chemical components derived from hydrolysis of magmatic volatiles and from intense rock leaching. The Cucaracho catchment receives input from warm acid brines with no free-gas phase but carrying a high load of hydrolyzed magmatic volatiles and rock-forming elements. One of these brines (Spring 4) is characterized by a sulfate-chloride chemical signature, medium temperatures of 27-38 °C, pH between 2 and 4 and TDS values between 780 and 1300 mg/L. Based on water and heat-balance considerations, chemical and stable-isotope signatures and groundwater transport modeling, it has been proposed that these acid springs represent brine water from the lake-hydrothermal system that is diluted by shallow groundwater permeating tephra layers (Kempter and Rowe, 2000).

Since Rincón′s latest phreatomagmatic activity in 1983, episodes of phreatic eruptions from the crater lake have been registered in 1983-87, 1991, 1995, 1998 and 2011. Some of these eruptions (VEI 1) have expelled large quantities of lake water, triggering small to medium- sized fast-moving acidic lahars running along effluents of the Cucaracho River. They affected communities and haciendas as far as 5 to 7 km downstream, destroying vegetation, infrastructure and wild life. After ca. 13 years of relative quiescence, phreatic eruptions in the crater lake renewed in August 2011 and continued intermittently throughout September-November, accompanied by visible signs of stronger convection. In the same period, continuous monitoring revealed a progressive rise in temperature (from 32.4 to 34.0°C) in Spring 4. This coincidence provides new evidence for the postulated hydraulic connection between the dilute acid springs at the NE flank of the volcano and the crater lake. We will present physico-chemical data that further support this link, and discuss the potential of geochemical monitoring of the springs for surveillance purposes, as their location is safer and more accessible than the active crater.

Reference: Kempter, K.A., Rowe, G.L. 2000. Leakage of active crater lake brine through the north flank at Rincón de La Vieja volcano, northwest Costa Rica, and implications for crater collapse. J. Volcanol. Geotherm. Res., 97: 143-160.