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The hydrothermal system of Piton des Neiges (Réunion Island, Indian Ocean): constraints from geochemical and C, O, H, Sr isotopes

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Piton des Neiges volcano is considered to be inactive since at least 12 ka, yet displays extensive evidence of hydrothermal activity. Here we report a comprehensive geochemical study (major and trace elements and Sr, C, O and H isotopes) of 65 hot springs, to understand the dynamics of Piton des Neiges' hydrothermal system.
Hydrothermal activity concentrates mostly in the cirques of Cilaos and Salazie, two of the three circular depressions of Piton des Neiges. The hot springs (max. temperature 49°C, max. conductivity 3.4 mS/cm, min. pH 5.7) can be classified according to their major element chemical composition as bicarbonate, chloride, sulfate waters or a combination of these types. Bicarbonate springs are located preferentially on the inner parts of the volcano whereas chloride and sulfate waters are located closer to the outer flanks. The δ13C values (- 4.5 to +5.15 ‰ of the total dissolved carbon indicate a magmatic carbon origin more or less changed by CO_2 degassing, whereas the δ18O, δD signature of waters is typically meteoric.
There is a clear trend of increasing δ18O, δD and 87Sr/86Sr values from hot springs of the cirque of Cilaos to those of Salazie: springs from Cilaos display a narrow range of δ18O, δD values (-8.5 to -6.7 ‰ and -56.3 to -41.4 ‰ respectively) and are depleted in 18O and D compared to rain, surface and ground waters from the study area (-8 to -1.6 ‰ for δ18O, and -51.3 to + 0.9 ‰ for δD). Cilaos hot springs also occur in the vicinity of large syenite intrusions and have the typical low 87Sr/86Sr signature of these rocks (0.704142 to 0.704249). In contrast, springs from the cirque of Salazie show a wider range of δ18O and δD (-8.6 to -4.9 ‰ and -54.8 to -23.5 ‰ respectively) comparable to that of superficial waters, and higher and more scattered 87Sr/86Sr ratios than those of Cilaos (0.704224 to 0.704336), in agreement with the signature of the host rocks from which they flow out.
From this spatial repartition of chemical and isotopic data, we interpret hot springs as originating from a common hydrothermal reservoir located below the syenite intrusives of Cilaos, and mixed with magmatic carbon. Away from this hydrothermal center and toward the cirque of Salazie, waters progressively interact with the whole variety of rocks from Piton des Neiges, and become diluted by superficial waters. These results are thus of prime importance for the prospection of geothermal energy at Piton des Neiges. The question remains whether Cl and S are also magmatic, which would imply that the heat source is a shallow degassing magma beneath the volcano.