

The origin of fumarolic fluids from Tupungatito Volcano (Central Chile): new insights from volatile compositions

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Tupungatito is an early Pleistocene – Holocene volcano located 100 km east of Santiago, in the northernmost sector of the South Volcanic Zone (SVZ) in Central Chile. Permanent fumarolic activity occurs at the Tupungatito summit (González – Ferrón 1995) where three crater lakes are hosted. In this study we present and discuss the very first chemical and isotopic ($\delta^{13}\text{C}$ – CO_2 , R/Ra, and $^{40}\text{Ar}/^{36}\text{Ar}$) composition of fumarolic gases and steam ($\delta^{18}\text{O}$ and δ^{D}) collected from this volcano during two sampling campaigns carried out in February 2011 and 2012. The main aims are to investigate the different fluid source regions and the chemical-physical processes controlling fluid chemistry.

The chemical and isotopic data indicate that the discharged gas species and steam are likely produced by mixing processes of fluids between a magmatic source rich in acidic gases (SO_2 , HCl and HF) and a meteoric – recharged hydrothermal reservoir. The magmatic – hydrothermal fluids at the surface are affected by steam condensation that controls the outlet fumarolic temperatures ($<84^\circ\text{C}$) favoring the dissolution of high soluble magmatic gases. The origin of CO_2 seems to be mainly related to devolatilization of the subduction carbonates, with a limited contribution from the overlying organic – rich sediments, suggesting that the mantle source is strongly contaminated by the slab sediments. Gas geothermometry based on the kinetically rapid H_2 – H_2O – CO – CO_2 system indicates equilibrium temperatures $>200^\circ\text{C}$ at redox conditions more oxidizing than those commonly characterizing hydrothermal reservoirs. Reactions involving CH_4 and C_2 – C_3 alkenes/alkanes pairs, having a relatively slow kinetics, seem to equilibrate at greater depth where temperatures are $>200^\circ\text{C}$ and redox conditions consistent with those inferred by the presence SO_2 – H_2S redox pair, typical of a magmatic fluid environment. A comprehensive conceptual geochemical model describing the circulation pattern of the Tupungatito hydrothermal – magmatic fluids is proposed to show fluid source regions and re – equilibration processes affecting the different gas species occurring at changing chemical – physical conditions as the magmatic – hydrothermal fluids rise up toward the surface.

By comparing the Tupungatito gas geochemical data with those discharging from other volcanic systems located in the northernmost sector of the Chilean Andes, it is possible to assess that i) different climate, ii) amount and composition of the subducted sediment, iii) slab thermal state, and iv) crustal thickness and lithology do not apparently play a significant influence on the gas chemistry.