Geochemistry and mineralogy of the hyper-acidic hydrothermal system of Dallol, Ethiopia

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Dallol hydrothermal system lies in the salty plain of the Danakil depression at the extension of the Main Ethiopian Rift, related to one of the most representative examples of continental rifting resulting to incipient seafloor spreading. During two expeditions in 2016 and 2017 we performed in situ measurements, collected liquids from both hydrothermal springs and pools, precipitates of different mineral patterns, and gases and we present new data about the hydrochemistry, mineralogy and isotopic analyses of the samples.

The highly dynamic hydrothermal activity of the site is manifested in numerous fumarolic fields and springs, both subaerial and subaqueous, that discharge O_2-free, hyper-acidic brines (pH near and below 0), of 105-108 °C temperature, supersaturated in NaCl, with more than 30 g/L of Fe. The spectacular colors of the liquids and solids that are characteristic of the site, are the result of the gradual diffusion of O_2 into the reduced brines and oxidation of the Fe and S aqueous species and nanoparticles. At the same time, cooling and subsequent evaporation of the brines lead to the precipitation of complex mineral patterns, composed of Na-/Fe-/K-/Ca-/Mg-salts and -sulfates and Fe-oxyhydroxides and -sulfides as was shown by FESEM-EDS, HRTEM, XRD and micro-RAMAN. Oxygen and hydrogen stable isotope ratios of the brines indicate a magmatic origin with meteoric water circulation and clearly distinguish Dallol dome from the neighboring sites of Yellow and Black lake. GC-MS and incubations with stable-isotopes labeled compounds confirm the absence of biological activity in the pristine, hyper-acidic spring water, but, indications of biological activity were detected in some pools. Our results show that unlike other terrestrial and submarine hydrothermal systems the geochemical characteristics of Dallol are not controlled by life. Thus, Dallol provides a unique, modern, geochemical analogue for early-Earth environments, before life appeared.