Oldoinyo Lengai gas chemistry from 2005 to 2009: Insights to carbonatite-nephelinite volcanism

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Abstract

The African Rift valleys are sites of carbonatite-nephelinite volcanic complexes. Oldoinyo Lengai (OL), the cone that rises to nearly 3000 m above Tanzania's Rift Valley, is the world's only active carbonatite volcano. Explosive eruptions have occurred at OL in 1966, 1983 [1] and 1993 [2] producing ash, cones and natrocarbonatite tephra. From Sept. 2007 to Nov. 2008, OL erupted explosively forming a ~60 m high ash cone. The magma composition of these eruptions is nephelinite mixed with carbonatite [3]. In June 2009, we observed a carbonatite lava lake at the bottom of the ~100m deep crater. Volcanic products at OL have therefore transitioned from carbonatite erupted in 2005/06 to nephelinite back to carbonatite in three years; a tribute to the highly dynamic nature of the volcano. We collected samples from crater fumaroles in July 2005, May 2006 and June 2009, spanning the volcanoes recent cycle of activity. The gas composition of all samples is dominated by H2O (meteoric) and CO2. S, HCl, and HF contents are < 1 mol%. Hydrogen and CO contents of 0.1 - 0.2 mol% and 0.0015 - 0.025 mol% respectively show the reduced nature of the gases consistent with H2S being the dominant S species. The CO2/S and CO2/HCl ratios of gases are lower than those of carbonatite magmas which contain up to 8000

ppm S and Cl suggesting that carbonatite acts as a condensor for S and Cl (see also [3]). Isotopic compositions of He, N2, Ar, C show that the mantle below OL is characterized by volatiles indistinguishable from those of MORB sources [4]. H2-H2O redox conditions indicate equilibrium with the `rock-buffer' commonly controlling gases associated with silicic magmas [5]. Gas equilibrium temperatures from ~ 400C to 600C are similar to carbonatite magmas (540C). The 2009 gases have CO2/S ratios that are higher by factor of 10 than those collected in the 2005 and 2006, suggesting efficient condensation of S into the erupting carbonatite ~ 100 m below the sampling locality. Alternatively, the low S contents could be attributed to volatile depletion of the underlying silicate magma during explosive eruptions. Abundances of non-condensable gases (CO2, He, N2, Ar) are indistinguishable from those of 2005. This is consistent with the idea that carbonatite magma is a shallow reservoir extending at most several 100's m below the current crater bottom and contributing minimally to the overall volatile budget which is dominated by degassing of the deeper and presumably much larger nephelinite magma. Our data provide important constrains on the nature of carbonatite magmatism and the underlying nephelinite as well as the interaction between these two magmas that produces alternating effusive and explosive eruptive activity. Refs: 1 Dawson, J.B. (1989) Carbonatites: Genesis and Evolution; 2 http://www.mtsu.edu/~fbelton/lengai.html; 3 de Moor et al., AGU Fall 09 abstract. [4] Fischer et al., nature 2009. [5] Giggenbach et al., 1987.