The 2005 and 2006 Eruptions Of Ol Doinyo Lengai: Assessing Deep and Shallow Processes At an Active Carbonatite Volcano Using Volatile Chemistry And Fluxes

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Abstract

The African Rift valleys are sites of classical carbonatite volcano complexes. Ol Doinyo Lengai, the spectacular cone that rises to nearly 3000 m above Tanzania's Eastern Rift Valley, is the world's only active carbonatite volcano. High-alkali carbonatite lavas from this volcano were first recognized in the 1960's and the oldest natrocarbonatite tuffs have been dated to 1250 years B.P.. Earlier eruptions produced phonolitic and nephelinitc lavas [1]. Since the 1960's the volcano has erupted frequently producing carbonatite lava flows. Explosive eruptions are much less frequent but have occurred in 1966, 1983 [1] and 1993 [3] producing ash, cones and natrocarbonatite tephra. In July 2005, we launched an expedition to the crater to collect gas and rock samples. On July 4, the volcano began erupting low viscosity, low T (540C) high velocity (2 m/sec) lava flows at a rate of about 0.3 m3/sec. By afternoon, the lava was flowing over the eastern crater rim. During the eruption we sampled gases from nearby hornitos at 120 and 168C, yielding pristine magmatic gases characterized by 75 mol% H_2O, 22% CO_2, < 1% SO_2, H_2S, HCl and traces of H_2, He, Ar, N_2, CH_4 and CO. CO_2-CH_4-CO gas equilibrium temperatures are 580C consistent with lava flow temperatures. N_2-He-Ar abundances indicate an upper mantle origin of volatiles, confirmed by isotopes [4]. SO_2 flux measured by mini DOAS was low (10 t/day). CO_2 fluxes calculated using CO_2/SO_2 are 3000 to 4000 t/day. Volatiles measured in the carbonatite lavas by SIMS show low H_2O (< 0.7 wt%), high S (0.2 to 1 wt%) and Cl (0.6 to 1.4

wt%) and variable F (0.06 to 0.7 wt%). CO2 contents are 30 wt% with major and trace elements typical of natrocarbonatite lavas previously reported in [1]. The release of all CO2 (30 wt% or 20 t/day) from eruption lavas would only produce a small fraction of the measured CO2. In March 2006 eyewitnesses [3] reported the occurrence of an explosive eruption and some of us returned to the volcano on May 12. The morphology of the crater had changed and was now filled with lava 2 m deep. The central cone area had collapsed. We sampled a deposit of carbonatite ash containing accretionary lapilli suggesting water-magma or water-ash interaction. The measured SO2 flux was low (approx. 10 t/day). Our data and observations imply that 1) Ol Doinyo Lengai gases originate from the upper mantle and have equilibrium temperatures consistent with carbonatite magmas, 2) the CO2 flux measured during the eruption cannot be produced by the eruption of carbonatite lavas and additional CO2 is released from the mantle, 3) explosive eruptions (such as in 2006) may be triggered by hydromagmatic processes. Alternatively the fountain material interacted with rain at the surface.