Gas-driven lava lake fluctuations at Erta 'Ale volcano (Ethiopia) revealed by MODIS measurements

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The permanent lava lake of Erta 'Ale volcano (Ethiopia) is remotely monitored by MODerate resolution Imaging Spectroradiometers (MODIS) installed on satellites. The Normalised Thermal Index (NTI) is shown to be proportional to the volume of the lava lake based on visual observations. The lava lake's variable level can be related to a stable foam trapped at the top of the magma reservoir, whose thickness changes in response to the gas flux feeding the foam being successively turned on and off.

The temporal evolution of the foam thickness, and the resulting variation of the volume of the lava lake, is calculated numerically by assuming that the gas flux feeding the foam, initially constant and homogeneous since December 9, 2002, is suddenly stopped on December 13, 2002 and not restarted before May 2003. The best fit between the theoretical foam thickness and the level of the lava lake deduced from the NTI provides an estimate of both the reservoir radius, 150-190 m, and the gas flux feeding the foam, 5.5x10-3-7.2x10-3 m3/s when existing. This is in agreement with previous estimates from acoustic measurements. The very good agreement between the theoretical foam thickness and that deduced from MODIS data shows for the first time the existence of a regime based on the behaviour of a stable foam, whose spreading towards the conduit can explain the permanent activity. The lava lake, when high, often shows regular rise and fall of its level. We have recognised a minimum of 26 very well marked cycles between January 2001 and December 13, 2002, corresponding to a typical return time of 10.8 +- 2.3 days and a gas volume of 8.3x105 +- 2.0x105 m3. This corresponds to a gas volume fraction in the reservoir equal to 0.03–0.12 pourcent. The yearly gas flux, estimated between December 13, 2002 and September 27, 2004, varies between 2.3x10-6 m3/s and 5.9x10-6 m3/s at the depth of the reservoir.