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Anatomy of an unstable volcano from InSAR: multiple processes affecting flank instability at Mt. Etna, 1994-2008

Valerio Acocella (1), Giuseppe Solaro (2), Susi Pepe (2), Joel Ruch (1), Marco Neri (3), and Eugenio Sansosti (2)

(1) Università Roma Tre, Dipartimento Scienze Geologiche, Roma, Italy (acocella@uniroma3.it, +39 06 5488 8201), (2) Istituto per il Rilevamento Elettromagnetico dell'Ambiente, Consiglio Nazionale delle Ricerche, Napoli, Italy, (3) Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Catania, Italy

Volcano deformation may occur under different conditions. To understand how a volcano deforms, as well as relations with magmatic activity, we study in detail Mt. Etna using InSAR data, from 1994 to 2008. From 1994 to 2000, the volcano inflates with a linear behaviour. The inflation is accompanied by eastward and westward slip on the E and W flanks, respectively. The portions proximal to the summit show higher inflation rates, whereas the distal portions show several sectors bounded by faults, in some cases behaving as rigid blocks. From 2000 to 2003, the deformation becomes non-linear, especially on the proximal E and W flanks, showing marked eastward and westward displacements, respectively. This behaviour results from the deformation induced by the emplacement of feeder dikes during the 2001 and 2002-2003 eruptions. From 2003 to 2008, the deformation approaches linearity again, even though the overall pattern continues to be influenced by the emplacement of the dikes from 2001 to 2002. The eastward velocity on the E flank shows a marked asymmetry between the faster sectors to the N and those, largely inactive, to the S. In addition, from 1994 to 2008 part of the volcano base (S, W and N lower slopes) experienced a consistent trend of uplift, on the order of 0.5 cm/yr. This study reveals that the flanks of Etna have undergone a complex instability resulting from three main processes. In the long-term (10^3-10^4 years), the load of the volcano is responsible for the development of a peripheral bulge. In the intermediate-term ($\leq 10^1$ years, observed from 1994 to 2000), inflation due to the accumulation of magma induces a moderate and linear uplift and outward slip of the flanks. On the short-term ($\leq$1 year, observed from 2001 to 2002), the emplacement of feeder dikes along the NE and S rifts results in a non-linear, focused and asymmetric deformation on the E and W flanks. Deformation due to flank instability is widespread at Mt. Etna, regardless of volcanic activity, and remains by far the predominant type of deformation on the volcano.