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# Multidisciplinary studies reveal interaction between magma accumulation, flank instability, and eruptions at Mount Etna, Italy

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Three important findings facilitated by multidisciplinary studies have governed recent research on the eruptive and structural behaviour of Mount Etna: (1) the eruptive behaviour is characterized by cycles both in the short and long term; (2) flank eruptions may be triggered by the slippage of the unstable eastern to southern sector of the volcano; (3) voluminous magma accumulation below the volcano leads to the formation of distinct, discrete reservoirs. These results have been possible due to the integration of geological, structural, seismic, and deformation data.

Short-term eruptive cycles that last several decades are observed since 1865 and substantially consist of three distinct phases: (a) a period of eruptive quiescence that last $<3.5$ years, (b) a period of more or less continuous summit activity lasting 6 to 16 years, and (c) a series of flank eruptions often with intervening summit activity, extending over 9 to 22 years. Long-term cycles extend over several centuries and equally

consist of three phases, the first of which is characterized by low levels of activity, mainly at the summit, whereas the second and third phases both have flank eruptions but these are far more frequent and more voluminous during the third, culminating phase.

Flank slip occurs frequently along numerous active faults from the Pernicana fault system on the northeast flank, over the S. Venerina and Mascalucia-Trecastagni faults to Ragalna fault system on the SSW flank, and seems to progressively involve several slide blocks that moved at different time and rate. In 2002 a major flank slip occurred in coincidence with, and probably served as a trigger for, a highly explosive and effusive eruption on the NE and S flanks of Etna. Flank slip recurred during the 1.5 years following that eruption and was in turn followed by a new flank eruption in 2004-2005. A feedback mechanism between flank instability and eruptions has therefore been proposed, and magma accumulation is suggested as the prime process leading to flank instability, as preceding the 2001 flank eruption, as documented by investigation of the pattern of $b$-value relatively to the pre-eruptive and eruptive period. The authors identified two volumes of anomalously high $b$-value one located $3\pm1$ km (under the volcano's summit) and at about $1\pm1$ km depth (under Valle del Bove) interpreted as two different steps of a magma migration process ended with the July-August 2001 eruption. The shallower anomaly is coinciding with the position and geometry of the uprising dike modelled by tilt and GPS data. The upward migration of magma is envisaged by us to have accelerated the process of near-continuous flank spreading and its culmination in the vigorous 2002 flank slip that in turn led to the 2002-2003 eruption.

Ongoing flank slip, probably caused by continued magma accumulation, eventually caused the opening of fractures on the upper SE flank of the volcano and the draining of magma (2004-2005) from the conduit of the Southeast Crater that had been stored there for more than three years.