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Understanding conduit dynamics and forecasting major strombolian explosions by ground-based radar interferometry

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Volcanic eruptions are preceded by a series of detectable phenomena related to: i) rise of magma and gas from deep, dike-filling intrusions, ii) increase in magma pressures within conduits, iii) inflation of volcanic edifices.. Ground deformation resulting from volcano inflation can be recorded by various techniques as the recent ground-based radar interferometry (GB-InSAR).

Here we present GB-InSAR deformation data (interferograms) collected at Stromboli volcano (Aeolian Islands, Southern Italy) over the period 2008-2011 to evidence that increase in deformation rate in the upper portion of the conduit system occurred before the onset of the very hazardous, "non-forecastable" "major" explosions.

"Major" explosions are high-intensity "variation on the Strombolian theme" and, until now, little precursors have been identified. At Stromboli they often occurr clustered within a short time period characterized by "anomalous" activity, that we define as "major-explosions dominated" period. During this phase, the enhanced explosive activity is often associated with lava emissions from the summit craters, and "ordinary" Strombolian activity appears more vigorous and frequent.

Medium, short and very-short term interferograms of the summit crater area of Stromboli,revealed increased patterns of deformation rate of the vent areas prior the onset of major explosions.

Both the base and the rim of the craters area are the involved in the deformation, with different timing before the occurrence of major explosive events. At the base of the crater, corresponding to the intersection of the summit area with the northern tip of the NE-SW trending dike-conduit, an increase in deformation rate is observed, starting from one week to one month before the onset of a major-explosions dominated period., At the crater rim an increase from high to very high deformation rate is shown about ten to twenty minutes and twenty to forty seconds before each major explosion.

We propose that the deformation patterns observed at the base of the summit area is associated to an upward compression in the area below the vent induced by the ascent of a volatile-rich, low-porphyritic, deeper magma, pushing the degassed, higly porphyritic magma residing in the upper portion of the magma column. We believe that a batch of more-deeply seated, uprising magma promotes the onset of the high-intensity, MED activity. On the other side, the pattern observed at the craters rim can be explained by pressurization of the upper conduit due to gas-slug expansion prior and coeval with the major explosions.

Our results suggest that continuous GB-InSAR volcano monitoring could prove insightful if applied to the study of crater areas, and hence to improve forecasting capabilities of high-intensity explosions at Stromboli and other "moderate-explosive" volcanic systems.