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Event Tree-like conceptual model for Mount Etna

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Abstract

Considering the peculiarities of the open conduit activity at Mount Etna, here we focused in the development of a dedicated event-tree-like conceptual model including all the potential activities that may occur at Mount Etna, including both central and lateral eruptions. This conceptual model represents the base for a further development of an exclusive dedicated probabilistic model, a study already ongoing in multiple Italian projects (e.g., AshResilience and IMPACT Projects). The general conceptual model presented here for the Etna eruptions, has been developed within the WP11 of the European project EUROVOLC.

Description

So far relatively few specific efforts have been dedicated to the development of Event Trees for eruption forecasting and/or probabilistic volcanic hazard assessment at Mount Etna. A first attempt of defining a Bayesian event tree for eruption forecasting is discussed in Brancato et al. (2012), who performed several elicitation experiments to introduce monitoring measures into the standard BET framework (Marzocchi et al., 2008, 2010). This event tree has not been further developed, and being quite simplified does not include many of the source complexities typical of open-conduit volcanoes, as inferable for well monitored volcanoes like Etna (e.g., Barberi et al., 2004; Bonaccorso et al., 2004; Del Negro et al., 2004; Napoli et al., 2008; Acocella and Puglisi, 2013; Carbone et al., 2019; Greco et al., 2016; Paonita et al., 2016; Privitera et al., 2012). Other efforts have been instead devoted to the development of networks for forecasting targeted volcanic eruptive style, e.g., the early warning of lava fountaining at summit craters based on Bayesian Belief Network (Cannavò et al., 2017), or two Machine Learning (ML) approaches, to classify volcanic activity using multivariate geophysical data, namely the Decision Tree (DT) and K-Nearest Neighbours (KNN) (Hajian et al., 2019).

Considering the peculiarities of the open conduit activity at Mount Etna, here we focused in the development of a dedicated event-tree-like conceptual model including all the potential activities that may occur at Mount Etna, including both central and lateral eruptions. This conceptual model represents the base for a further development of an exclusive dedicated probabilistic model, a study already ongoing in multiple Italian projects (e.g., AshResilience and IMPACT Projects).

The general conceptual model presented here for the Etna eruptions, has been developed within the WP11 of the European project EUROVOLC. This model results from a deep iterative discussion among the Authors of the present document, by means of several meetings aimed at explore consensually sharing the strength between volcanic processes and indication observed in monitored parameters at Etna. The study improves and integrates a preliminary conceptual model developed in the Italian project AshRESILIENCE (Progetto Premiale INGV 2015).

The retrieved conceptual model (Fig. 1) considers a classification of the volcanic activities in three different levels defining monitoring anomalies (level 1), states of the system (level 2, orange boxes in figure 1), and target events (level 3, red boxes in figure 1), respectively. Similarly to Bayesian belief network diagrams (e.g., Hincks et al., 2014), the novel model considers to tackle the relationship between what can directly be instrumentally measured at Mount Etna (level 1) to what can be observed during the eruption (level 3) via hypothetical not observable states or processes occurring in the volcano edifice (level 2).

Volcanic processes (level 2) encompass different recharging states of the volcano from the deep (depth > 8 km bsl) to the shallow feeder system (inside the edifice, at heights > 1 km asl) via intermediate levels (Fig. 2a and b). Intermediate recharges may either evolve into vertical\eccentric, horizontal\radial dikes, potentially leading to lateral eruptions, or migrate through the conduit toward the shallow system. In a row, shallow recharges may either evolve into horizontal\radial dykes, leading to high quote lateral eruptions, or continue the migration along the conduit, leading to explosive vs. effusive summit eruptions, depending on the degassing state (abundance of gas) of magma at shallow level. Each specific hazardous events (level 3, including Intra-conduit failures, flank collapses, phreatic eruptions, explosive and effusive summit or sub-summit eruptions, lateral eruptions, all processes-related observed products) is connected to one or more of the level 2 states.

The volcanic processes described in Level 2 can have transitions among them and toward eruptive phenomena (Level 3). Each process and transition is characterized by specific monitoring anomalies

(Level 1), considering geophysical and geochemical time series. The specific definition of Level 1 is still ongoing, and it will be matter of future developments.

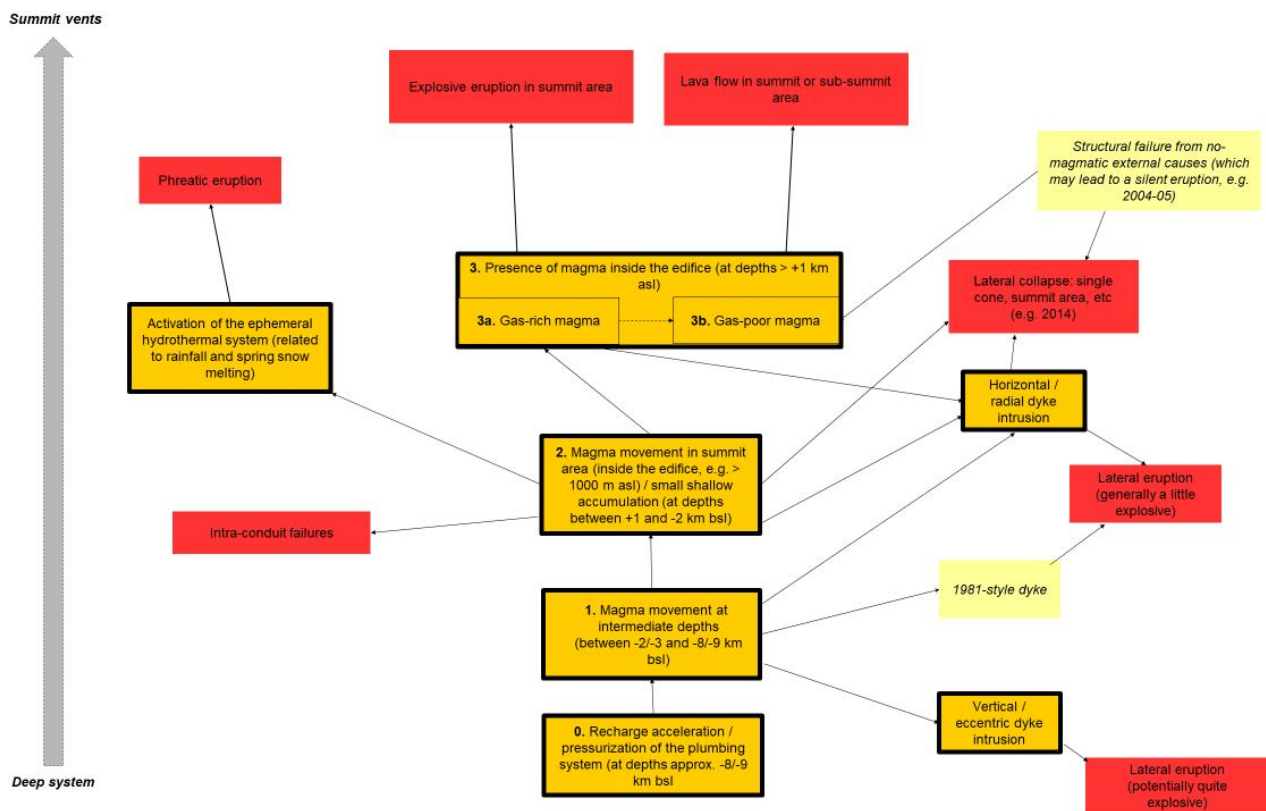
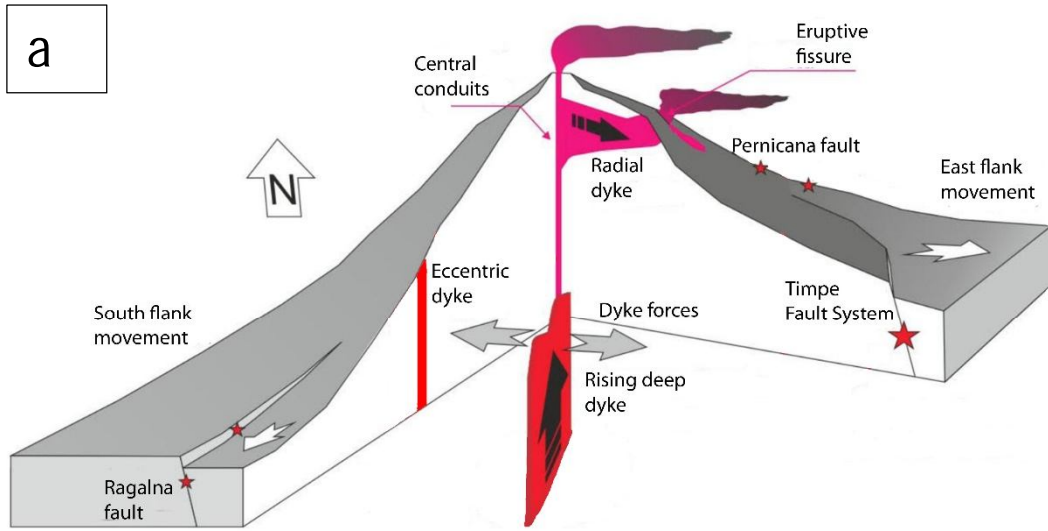


Fig. 1. Conceptual model for Etna activity. The model includes states of the system (orange boxes), the transitions among them (arrows) and the target events (red boxes). In pale yellow some examples and potential external factors that may trigger eruptions.



Deep source

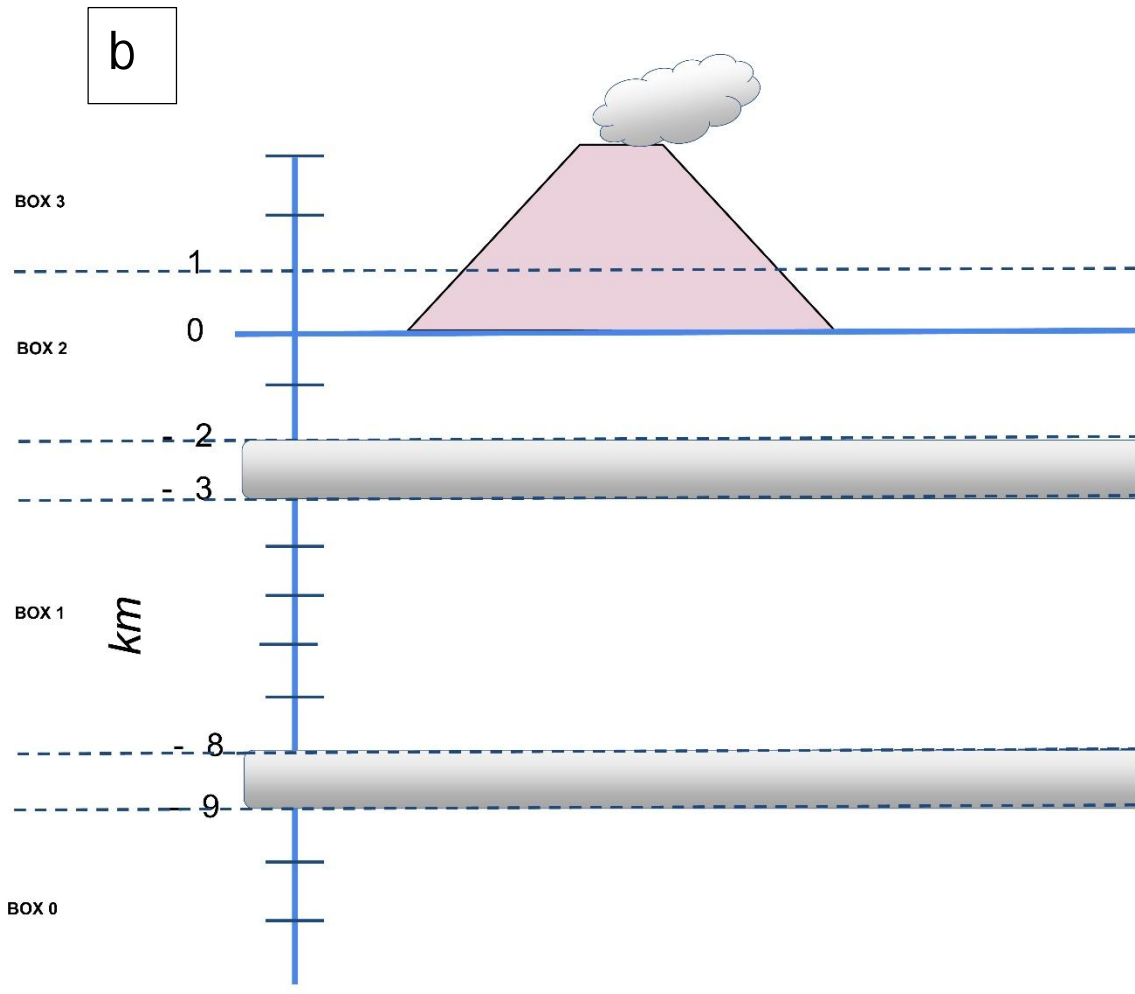


Fig. 2. Schematic view of the structure of Mt. Etna (a) with the depth of the transitions between processes (orange boxes reported in figure 1) (b).

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