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Structural features of an active strike-slip fault on the sliding flank of Mt. Etna (Italy)

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Abstract

The strike-slip Pernicana fault system (PFS) was activated along the eastern flank of Mt. Etna during an earthquake in September 2002 and, one month later, during the eruption of the NE Rift. Structural and volcanological data suggest that the PFS was activated as a result of the slide of the NE flank of Etna. This activation produced surface fracturing on walls and on paved and unpaved roads. The segments of the PFS, arranged in a right stepping en échelon configuration, show (a) an inverse proportion between length and frequency; (b) fractal behavior over scales of 10^{-2}–10^{1} m, between their length, overstep and overlap; (c) consistent strike with regard to their fault array; and (d) a progressive eastward decrease in the displacement, along the smallest faults. The consistent geometric and kinematic features of the PFS, related to the sector collapse of Etna, are similar to those of faults in strike-slip settings.

Keywords: Active faulting; Strike-slip faults; Fractal behavior; Volcano collapse; Mt. Etna; Pernicana fault system

1. Introduction

Fault zones usually consist of closely-spaced fractures, formed through repeated tectonic events (e.g. Scholz, 1990). Since most of the segments are linked, these fault zones mainly give information on the advanced and/or mature stage of evolution of a fault zone.

Several studies have been made on fault zones developed during a single rupture, where most of the linkage through the segments has yet to occur; this usually occurs for small displacements of the faults affecting undeformed rocks or deposits. The best-known cases of fault zones developed in a single rupture consist of surface fractures related to earthquakes (e.g. Angelier and Bergerat, 2002; Angelier et al., 2003; Bergerat et al., 2003) or to episodes of magmatic activity (e.g. Rubin and Pollard, 1988; Billi et al., 2003; Lanzafame et al., 2003). These types of fault zones may give information on the very early stages of development of a fault zone, such as its formation, revealed by the spatial configuration of the fault segments and their possible processes of interaction (e.g. Koukouvelas et al., 1999; Acocella et al., 2000). The possibility to observe the continuous development of a fault zone, from its growth to its final development, is commonly achieved through experimental (Cox and Scholz, 1988; An and Sammis, 1996a; An, 1998) or numerical models (Segall and Pollard, 1980; Olson and Pollard, 1991; An and Sammis, 1996b; Willemse, 1997; Gupta and Scholz, 2000).

The 2002–2003 Etna eruption and its associated events permitted observation of the activation of an ~18-km-long active strike-slip fault, the Pernicana fault system (Acocella et al., 2003; Neri et al., 2004), mainly on paved and unpaved roads on the flank of the volcano. The different amounts of displacement along the fault, decreasing eastward by one order of magnitude, also gives the rare opportunity to appreciate and compare the growth of portions of the same structure.

In this work, we summarize the main structural features related to the development of this fault zone.

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2. Geological background

The active fault developed during the 2002–2003 Etna eruption is located along the Pernicana fault system (PFS in Fig 1), one of the longest faults and most active in the Etnean area (Neri et al., 1991; Groppelli and Tibaldi, 1999). Mt. Etna is an active basaltic volcano located in eastern Sicily, at the front of the Apennine–Maghrebian Chain (Lanzafame et al., 1997; Fig. 1).

Volcanic activity at Mt. Etna is either focused at its four summit craters or occurs from fissures that are mainly concentrated in three so-called rift zones (Garduño et al., 1997; Behncke and Neri, 2003): the NE Rift, the S Rift and the W Rift (Fig. 1). Several studies present evidence for large scale sliding of the eastern and southern sectors of the volcano towards the E and S, respectively (Neri et al., 1991; Borgia et al., 1992, 2000; Lo Giudice and Rasà, 1992; Rust and Neri, 1996; Garduño et al., 1997; Froger et al., 2001;

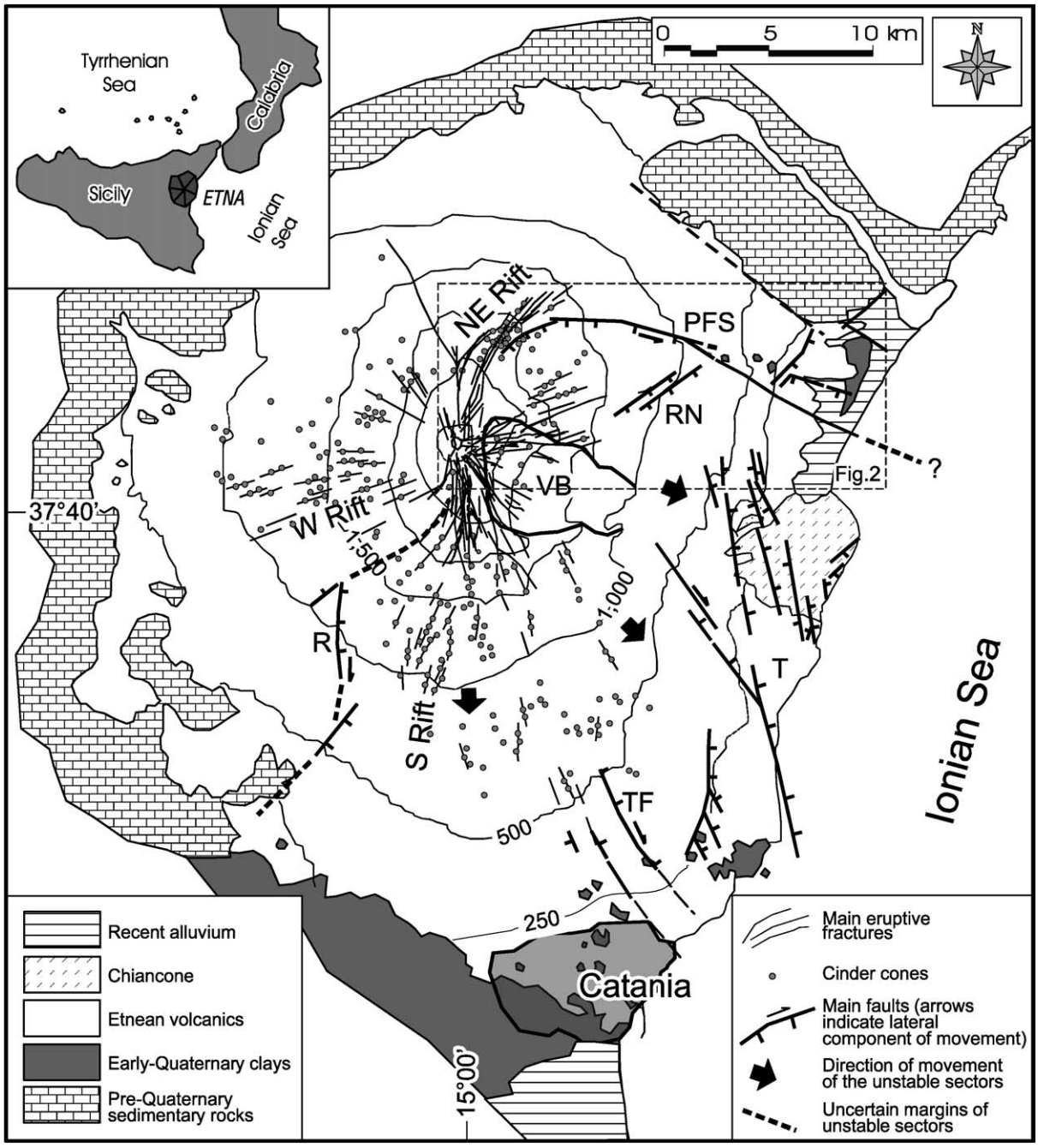

Fig. 1. Geological and tectonic map of Mount Etna. The boundaries of the unstable sector of the volcano are taken from Borgia et al. (1992) and Rust and Neri (1996). The sedimentary basement is made up of units of the Apenninic–Maghrebian Chain (North and West) and of early Quaternary clays (South). VB = Valle del Bove; PFS = Pernicana fault system; RN = Ripe della Naca Faults; T = Timpe Fault System; TF = Trecastagni–Mascalucia Faults; R = Ragalna Faults.