Journal of Geodynamics 47 (2009) 288–292

Contents lists available at ScienceDirect

Journal of Geodynamics

journal homepage: http://www.elsevier.com/locate/jog

Technical note

Structural features of Panarea volcano in the frame of the Aeolian Arc (Italy): Implications for the 2002–2003 unrest

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ARTICLE INFO

Article history:
Received 8 October 2008
Received in revised form 13 January 2009
Accepted 13 January 2009

Keywords:
Arc volcanoes
Extension
Unrest

ABSTRACT

Panarea, characterized by gas unrest in 2002–2003, is the volcanic island with the least constrained structure in the eastern-central Aeolian Arc (Italy). Based on structural measurements, we define here its deformation pattern relative to the Arc. The main deformations are subvertical extension fractures (63% of data), normal faults (25%) and dikes (12%). The mean orientation of the extension fractures and faults is ~N38°E, with a mean opening direction of N135° ± 8°, implying extension with a moderate component of dextral shear. These data, matched with those available for Stromboli volcano (pure opening) and Vulcano, Lipari and Salina volcanoes (predominant dextral motions) along the eastern-central Arc, suggest a progressive westward rotation of the extension direction and an increase in the dextral shear. The dextral shear turns into compression in the western arc. The recent unrest at Panarea, coeval to that of nearby Stromboli, may also be explained by the structural context, as both volcanoes lie along the portion of the Arc subject to extension.

1. Introduction

Defining the shallow structural configuration of a volcanic arc is fundamental for understanding the behavior of active and quiescent volcanoes at convergent settings. Volcanoes usually show a consistent along-arc structural setting, characterized by compression (NE Japan; Sato, 1994), strike-slip motions (Mexican belt; Tibaldi, 1992) or predominant extension (Taupo Volcanic Zone, New Zealand; Spinks et al., 2005). Significant structural variations are expected along longer arcs (Aleutians or Andes), where the direction of the arc changes with respect to that of plate motion.

The micro-Aeolian volcanic Arc, <200 km long, lies within the back-arc Tyrrhenian basin and is related to the NW-directed subduction of the Ionian slab below Calabria (Southern Italy; Fig. 1; Barberi et al., 1974; Gvirtzman and Nur, 1999; Chiarabba et al., 2008). It consists of a central portion (Vulcano, Lipari and Salina islands), N20°W aligned; an eastern arc (Stromboli and Panarea islands), NE-SW trending; and a western arc (Alicudi and Filicudi islands), WSW-ESE trending (Fig. 1a). Volcanism occurred between 1.3 Ma and 3040 years in the western arc, from 0.8 Ma to present in the eastern-central arc (De Astis et al., 2003, and references therein), with documented coeval unrests, such as in 2002–2003 (degassing at Panarea and effusive eruption at Stromboli). A lack of deep seismicity (>20 km) in the western arc suggests active subduction in the eastern sector only (De Astis et al., 2003, and references therein). While the western arc undergoes predominant compression (De Astis et al., 2003), the eastern arc undergoes predominant extension (De Astis et al., 2003; Neri et al., 2005; Billi et al., 2006).

The structural features of the eastern-central Aeolian Arc have been mostly investigated at Vulcano, Lipari, Salina (Mazzuoli et al., 1995; De Astis et al., 2003) and Stromboli (Tibaldi et al., 2003; Tibaldi, 2004). The Vulcano–Lipari–Salina alignment lies along a NNW-SSE trending dextral transtensive system (Tindari–Letojanni), controlling volcanic activity (Fig. 1b; Ventura et al., 1999) and surface expression of a tear in the slab (Gvirtzman and Nur, 1999; Billi et al., 2006). Stromboli is characterized by NE-SW trending extensional structures, controlling active volcanism and sector collapse (Tibaldi et al., 2003; Tibaldi, 2004).

The tiny NNE-elongated island of Panarea lies between Stromboli and Salina (Fig. 1a). Subaerial volcanism occurred between 200 and 8 ka (Gabbianelli et al., 1990; Calanchi et al., 1999; Lucchi et al., 2003). Most eruptive structures arising from this period cluster along the western coast, ~NNE-SSW trending, but NE-SW and NW-SE trending systems are present (Fig. 2; Lanzafame and Rossi, 1984; Calanchi et al., 1999). In 2002–2003, a submarine gas eruption, possibly related to the uprising of magmatic fluids, occurred ~2 km E of Panarea. A significant part of the associated fractures display the main strike of the NE-SW regional structures (Chiodini et al., 2006, and references therein; Esposito et al., 2006).

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doi:10.1016/j.jog.2009.01.004

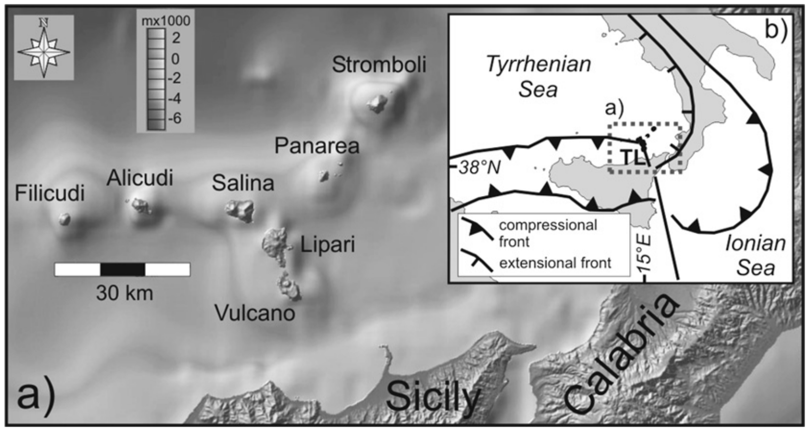

Fig. 1. The Aeolian Arc (a) and its tectonic setting (b).

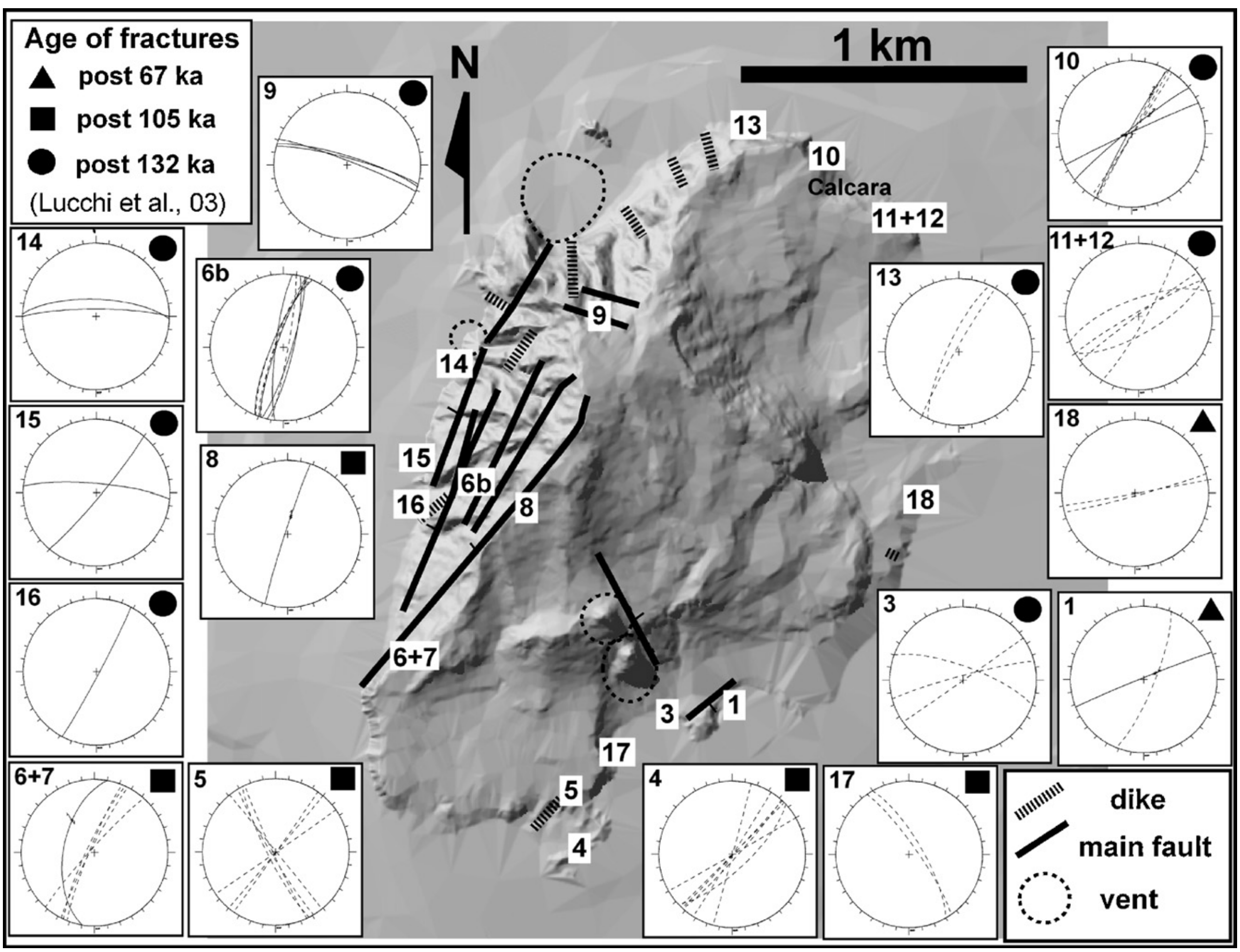

Fig. 2. Structural features of Panarea, on Schmidt's lower hemisphere nets; numbers, measurement sites; solid lines, faults; dashed circles, vents; symbols in upper right of plots, maximum age (Lucchi et al., 2003) of fractures.

Despite the many investigations at Panarea (Lanzafame and Rossi, 1984; De Astis et al., 2003, and references therein; Anzidei et al., 2005; Esposito et al., 2006), its onshore structural features are the least defined within the central-eastern Aeolian Arc, and a systematic structural approach is lacking. This work uses an original structural analysis at Panarea, to: (a) define its volcano-tectonic features and (b) place these in the tectonic context of the Arc, trying to explain its unrest in the regional frame.

2. Structural features of Panarea

To have a representative dataset, we considered previous descriptions of the deformations at Panarea (Lanzafame and Rossi, 1984; Calanchi et al., 1999, and references therein) and incorporated these into an original and systematic structural analysis.

The field analysis recognized 77 elements, consisting of extension fractures (63% of data), faults (25%) and dikes (12%). The limited