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Late Quaternary deformation on the island on Pantelleria: New constraints for the recent tectonic evolution of the Sicily Channel Rift (southern Italy)

Stefano Catalano[a], Giorgio De Guidi[a], Gianni Lanzafame[b], Carmelo Monaco[a], Luigi Tortorici[a,*]

[a] Dipartimento di Scienze Geologiche, Università di Catania, C.so Italia 55, 95129 Catania, Italy
[b] Istituto Nazionale Geofisica e Vulcanologia, sezione di Catania, P.zza Roma 2, 95123 Catania, Italy

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ABSTRACT

Structural observations carried out on the volcanic Island of Pantelleria show that the tectonic setting is dominated by NNE trending normal faults and by NW-striking right-lateral strike-slip faults with normal component of motion controlled by a ≈N 100°E oriented extension. This mode of deformation also controls the development of the eruptive fissures, dykes and eruptive centres along NNE–SSW belts that may thus represent the surface response to crustal cracking with associated magma intrusions. Magmatic intrusions are also responsible for the impressive vertical deformations that affect during the Late Quaternary the south-eastern segment of the island and producing a large dome within the Pantelleria caldera complex. The results of the structural analysis carried out on the Island of Pantelleria also improves the general knowledge on the Late Quaternary tectonics of the entire Sicily Channel. ESE–WNW directed extension, responsible for both the tectonic and volcano-tectonic features of the Pantelleria Island, also characterizes, at a greater scale, the entire channel as shown by available geodetic and seismological data. This mode of extension reactivates the older NW–SE trending fault segments bounding the tectonic troughs of the Channel as right-lateral strike-slip faults and produces new NNE trending pure extensional features (normal faulting and cracking) that preferentially develop at the tip of the major strike-slip fault zones. We thus relate the Late Quaternary volcanism of the Pelagian Block magmatism to dilatational strain on the NNE-striking extensional features that develop on the pre-existing stretched area and propagate throughout the entire continental crust linking the already up-welled mantle with the surface.

1. Introduction

The Island of Pantelleria, as for Linosa, represents the top of a large active composite Quaternary volcano belonging to the magmatic district of the Sicily Channel. Offshore geophysical and geological information (Calanchi et al., 1989; CNR, 1991; Grasso et al., 1993; Rotolo et al., 2006; Civile et al., 2008) show that the magmatic district of the Sicily Channel, which is part of the Pelagian Block (Burollet et al., 1978), includes several submerged volcanic edifices. Their distribution, that has been usually considered to have a NW–SE alignment, actually depict, as a whole, a roughly N–S oriented belt crosscutting the entire channel from the surroundings of the island of Lampedusa, to the South, to the Graham Bank, to the North (Fig. 1). N–S trend of the submarine volcanic centres is also recognizable at a local scale as shown by morphotectonic analyses carried out on detailed bathymetric maps of the Graham Bank area (Civile et al., 2008). The volcanism is mainly characterized by basic and poorly evolved products and only subordinately by evolved rocks exposed on the Island of Pantelleria and dragged on a seamount located at about 30 km to the E (Rotolo et al., 2006). Magmatism displays alkaline, peralkaline and tholeiitic affinities and it has been related to the occurrence of extensional tectonics that, during Late Neogene-Quaternary times, caused the development of three major distinct tectonic depressions (Pantelleria, Linosa and Malta troughs). These features, from a morphological point of view, are defined by deep furrows with depths of about −1300, −1500 and −1700 m in the Pantelleria, Linosa and Malta troughs, respectively (Morelli et al., 1975). Available seismic reflection lines (Finetti, 1984; Torelli et al., 1991; Finetti and Del Ben, 2005) show that these depressions, partially filled by Pliocene–Pleistocene turbidites reaching thicknesses of about 1000, 2000 and 1500 m in the Pantelleria, Linosa and Malta basins, respectively (Colantoni, 1975; Maldonado and Stanley, 1977; Winnock, 1981; Calanchi et al., 1989), are bounded by NW–SE trending sub-vertical conjugate normal faults (Fig. 1). The crustal stretching was associated with thinning of the African continental crust (Colombi et al., 1973; Boccaletti et al., 1984; Scarascia et al., 2000) that reaches thicknesses of 17–18 km beneath the Pantelleria and Linosa troughs (Finetti and Del Ben,

* Corresponding author.
E-mail address: tortoric@unict.it (L. Tortorici).

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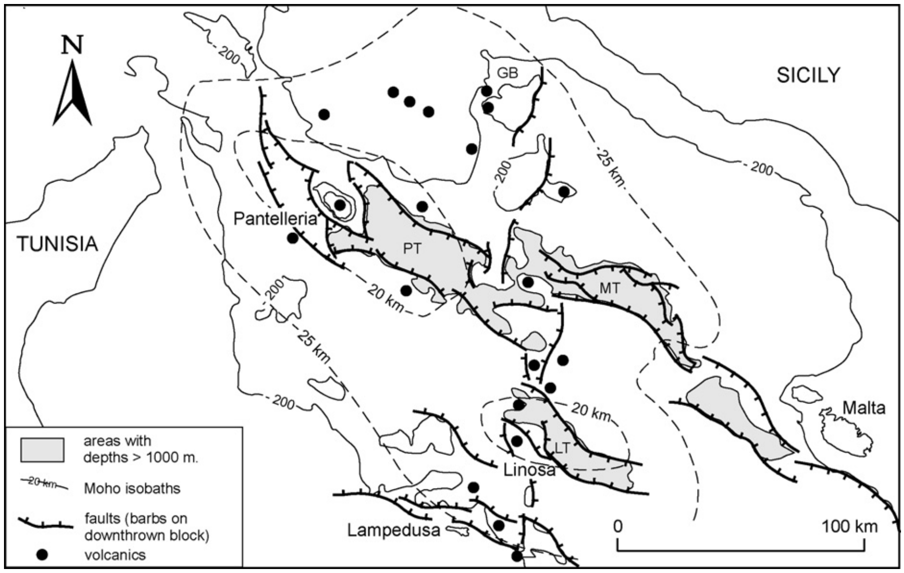

Fig. 1. Schematic structural map of the Sicily Channel. PT: Pantelleria trough; MT: Malta trough; LT: Linosa trough; GB: Graham bank. Location of volcanic centres are from Calanchi et al. (1989), CNR (1991), Grasso et al. (1993), Rotolo et al. (2006) and Civile et al. (2008); Moho isobaths are from Finetti and Del Ben (2005).

2005; Civile et al., 2008). These areas are also characterized by a relatively high heat-flow as high as 130 mW/m^2 (Della Vedova et al., 1995) and by positive Bouguer anomalies ranging between +40 and +80 mGal (Morelli et al., 1975). In order to explain the overall tectonic setting of the Sicily Channel in the framework of the geodynamic evolution of the central Mediterranean different models have been proposed. The structures of the Sicily Channel have been interpreted as an intraplate rift related to the NE-directed displacement of the northern part of the Pelagian Block including Sicily, away from the Africa continent (Illies, 1981; Winnock, 1981; Beccaluva et al., 1983; Finetti, 1984; Corti et al., 2006). The tectonic depressions of the Sicily Channel have also been interpreted as large and discrete pull-apart basins involving deep crustal levels that developed in front of the Africa-Europe collisional belt within a large dextral wrench zone (Cello et al., 1985; Jongsma et al., 1985; Reuther and Eisbacher, 1985; Ben-Avraham et al., 1987; Boccaletti et al., 1987; Cello, 1987; Reuther, 1990; Finetti and Del Ben, 2005). A further interpretation is proposed by Argnani (1990) who suggests that the rifting is due to mantle convections developing during the rollback of the African lithosphere beneath the Tyrrhenian basin. In this paper we present new geological data from the Pantelleria Island based on structural analyses carried out on the different sets of structures affecting the volcanic products of the island and on morpho-structural investigation of the major volcano-tectonic features accompanied by a detailed levelling of the main Holocene raised palaeoshorelines. The collected data provide new constraints for defining the Late Quaternary kinematics of the major tectonic lineaments characterizing the Pantelleria Island in terms of the regional setting of this portion of the Pelagian Block and for evaluating the modes and the rates of the Holocene vertical deformation in order to test possible relations between tectonic deformation and volcanism.

2. Structural features of the Pantelleria Island

The Island of Pantelleria consists entirely of volcanic rocks erupted from about 300 to 3 ka BP (Mahood and Hildreth, 1986). The volcanic products, grouped in distinct eruptive cycles (Civetta et al., 1988), are dominantly represented by acidic rocks, mainly peralkaline rhyolites (pantellerites) with subordinate trachytes and minor transitional basalts that crop out only in the north-western portion of the island (Civetta et al., 1984, 1988; Mahood and Hildreth, 1986). The volcanic activity of Pantelleria was mainly explosive and produced large volumes of ignimbrites and pyroclastics associated with the development of large volcano-tectonic collapses that, forming as a whole a caldera complex (*sensu* Cole et al., 2005), occur at present in the south-eastern portion of the island (Civetta et al., 1984, 1988). The most impressive ignibritic episode caused the emplacement, at about 45 ka BP, of the "Green Tuff" that drapes all the pre-existing volcanic features on the whole island and represents a well-defined stratigraphic key-horizon useful for defining the youngest volcanic activity of the island. An analysis of the most recent volcanics shows that the acidic products erupted in the south-eastern areas during the last 45 ka derive from the differentiation of primary basic magmas stored at a shallow-depth (3–4 km) chamber (Civetta et al., 1988). Its presence is also suggested by the thermal anomalies that characterize the island (Squarci et al., 1994). The most recent eruption of Pantelleria was submarine and occurred in 1891 about 5 km NW of the western coast of the island (Riccò, 1892; Washington, 1909). The structural setting of the island (Fig. 2) is defined by different volcano-tectonic features and by tectonic structures mainly comprising fault segments and minor fracture systems that usually affect the entire volcanic succession.

2.1. Volcano-tectonic structures

The major volcano-tectonic features exposed on the island are represented by caldera rims, emission centres and dyke swarms. The most impressive feature is constituted by a caldera complex formed by two large nested calderas that developed on the south-eastern portion of the island (Fig. 2). The oldest caldera, named La Vecchia Caldera by Mahood and Hildreth (1986) or Serra Ghirlanda Caldera by Cello et al. (1985), is defined by a of 2-km-long remnant rim that, completely mantled by the ≅45-ka-old Green Tuff, bounds to the west, with a maximum height of 100 m, the arc-shaped Serra Ghirlanda ridge. Volcanic horizons exposed on small sections along the southern coastal cliff of the island on relics of palaeo-escarpments attributed to La Vecchia caldera rims, constrains the age of this volcano-tectonic collapse to between 175 and 106 ka (Mahood and Hildreth, 1986). The more recent Zichidi Caldera (Cello et al., 1985), that corresponds to the Monastero Caldera of Cornette et al. (1983) and to the Cinque Denti Caldera of Mahood