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High resolution aeromagnetic anomaly map of Mount Etna volcano, Southern Italy

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ABSTRACT

A high resolution aeromagnetic survey of Mount Etna Volcano was carried out by the Airborne Geophysics Science Team of Istituto Nazionale di Geofisica e Vulcanologia (INGV), aimed at producing the most detailed magnetic anomaly map existing so far for this area. Two datasets of the total intensity of the Earth's Magnetic Field were collected at different altitudes to take into account the huge topographic variations of Etna volcano, that reaches elevations above 3300 m asl. One level was flown at the altitude of 2200 m whereas a second one over the central part, at about 3500 m of altitude. Since the region is characterized by a large presence of strongly magnetized volcanic products, the survey was carried out acquiring profile lines only, in order to optimize the resources. From the residual magnetic anomaly analysis we inferred two main trending lineaments (−35°N and 0°N) that are related to regional tectonic stress field and we interpret the main magnetic anomaly as the effect of thickness variation of magnetized volcanic products due to the complex pre-volcanic basement morphology of Etna.

1. Introduction

Mount Etna, one of the most active volcanoes in the world in a densely populated area, is a highly hazard-prone area, due to the volcanic activity and to the active sismogenetic structures triggering tsunami sector collapse occurrence (Pareschi et al., 2006). Etna is located in the Eastern side of the Sicily region (Fig. 1) and is one of the most studied volcanoes. During the last years, in fact, different parameters are constantly monitored, such as long term ground deformation (Monaco et al., 1997; Azzaro, 1999), short term ground deformation (Bonforte et al., 2011), gas geochemistry, and gravimetric and magnetic time variations on ground reference stations (Del Negro et al., 2002). Its internal structure was modeled using geophysical methods like seismic tomography from arrival times of compressional waves (Aloisi et al., 2002; Chiarabba et al., 2004; Patanè et al., 2006), from attenuation of seismic waves (De Gori et al., 2005), from 3D gravity model (Schiavone and Loddo, 2007) and some magnetotelluric inversion profiles (Siniscalchi et al., 2012 and references therein). The main result of these studies is the discovery of the high Vp and high density anomaly body interpreted as a relict intrusive system related to the earliest central type polygenetic volcanoes (Valle del Bove Supersynthem Branca et al., 2011).

The area was already covered by lower resolution aeromagnetic data carried out by ENI Divisione Agip during the 70s (Agip spa, 1981), in the framework of an aeromagnetic mapping of the Italian territory. A ground-based compilation of the magnetic observations conducted during the 70s (Chiappini et al., 2002) revealed, inter alia, the need of higher resolution measurements.

A small area of 30 × 20 km over the Eastern sector of Etna was surveyed and modeled by an aeromagnetic method (Rollin et al., 2000) highlighting the presence of highly magnetized intrusive body nearby Valle del Bove walls.

In May 2012 a high resolution, helicopter-borne aeromagnetic campaign was conducted by the Airborne Geophysics Science Team of Istituto Nazionale di Geofisica e Vulcanologia (INGV), covering completely all the Etna volcanic province around an area of about 60 × 60 km, including both onshore and offshore sectors. In order to take into account high topographic variations of Mount Etna, two surveys at different constant elevations were acquired to optimize the magnetic signal sampling: survey A was flown at an altitude of 2200 m whereas B, covering the central portion of Etna volcano, was performed at 3500 m asl (Fig. 2). We resolved the largest amount of magnetic anomalies over Etna volcanic area acquiring survey lines only rather than survey and tie lines together. In volcanic areas, characterized by extremely high magnetic anomaly intensities, the overall magnetic anomaly field can be obtained by flying at constant altitude (Chiappini et al., 2002; Blanco-Montenegro et al., 2007, 2011; De Ritis et al., 2010); in such a case, tie line correction does not add a significant contribution to data quality since it deals with values that are orders of magnitude lower than the main anomaly. Moreover, due to budgetary constraints, we preferred to cover the entire Etna volcano province at high resolution by means of survey lines, rather than doing it on a smaller area with

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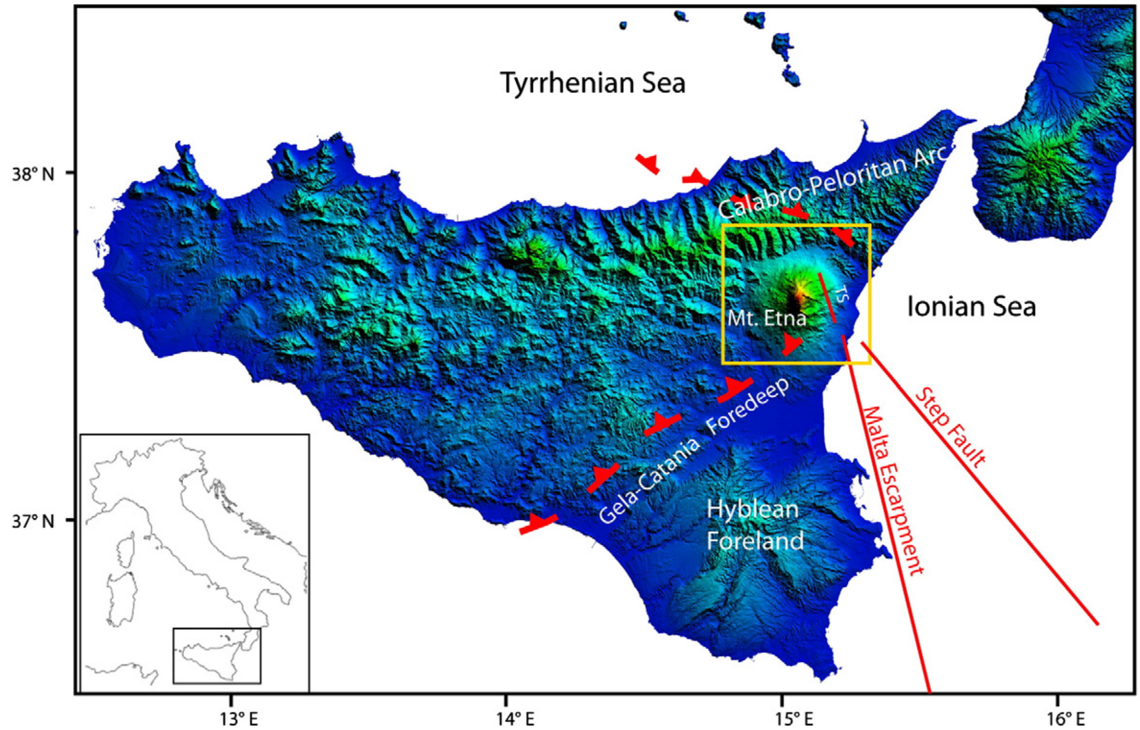

Fig. 1. Sicily and Etna main tectonic lineaments. Red lines = main fault systems; red triangle dashed line = main regional thrusts; TS = Timpe Fault System. Yellow box = survey area.

tie lines. We corrected the level errors using accurate diurnal variation data and applying a small amount of micro-leveling numerical procedure.

In this paper we present the results of the aeromagnetic data processing and the new high resolution aeromagnetic map of Etna. We discuss the magnetic signature of Etna and the surrounding areas using a reduction to the pole map and an azimuth analysis of identified magnetic picks.

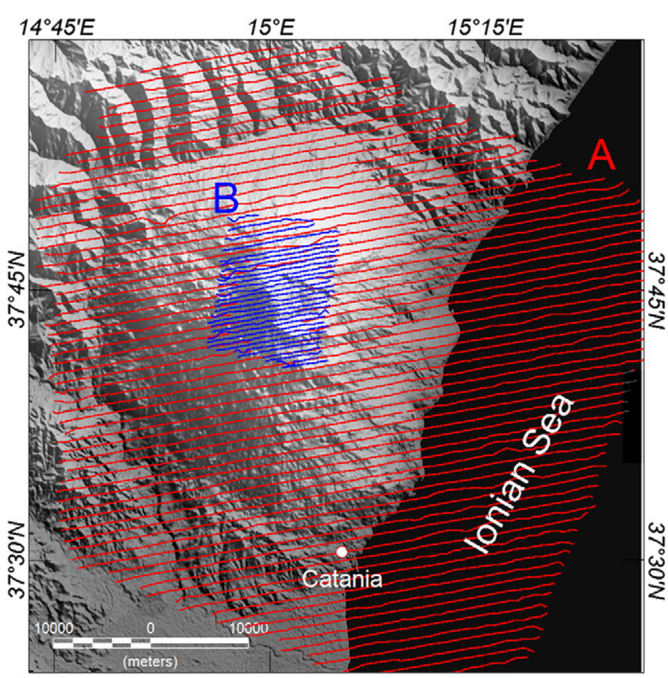

Fig. 2. Etna STRM Dem and survey line profiles. Red = survey A (altitude 2200 m), Blue = survey B (altitude 3500 m).

2. Geological settings

Mount Etna is a large basaltic strato-volcano, characterized by the alternation of effusive and explosive activity. The volcano lies between the Calabro-Peloritan Arc to the north and the carbonate and volcanic rocks of the Hyblean foreland to the south, belonging to the northernmost part of the African plate (Fig. 1) (Bousquet and Lanzafame, 2004). Etna is located in an active and complex tectonic framework, where important structural lineaments play a significant role in the dynamic processes of the volcano. Mount Etna, in fact, lies north to Gela-Catania foredeep, south-east to the Apennine thrust and is bordered to its eastern flank by the Ionian Sea, where the termination of the NNW–SSE Malta Escarpment occurs (Bianca et al., 1999; Argnani and Bonazzi, 2005). This Quaternary volcano rises up to 3300 m and covers an area about 1250 km^2. The beginning of Etna volcanism was due to the northward migration of Plio-Pleistocene Hyblean magmatic sources. Branca et al. (2011), on the basis of the stratigraphic data integrated with $^{40}Ar/^{39}Ar$ age determinations of De Beni et al. (2011), suggest an updated geological evolution of the Mount Etna stratovolcano. They propose four main eruptive phases. The first one, named Basal Tholeiitic Supersynthem, is a fissure type eruption that started on the seafloor and then took place in subaerial environment from about 500 to 330 ka; a second intense eruptive phase, influenced by the extensional tectonics of the NNW-trending Timpe fault system (TS) (Branca et al., 2008), started 220 ka, forming a lava shield of the Timpe Supersynthem; 110 ka, during the Valle del Bove Supersynthem, the central type eruption occurred with the construction of the earliest three volcanoes of Tarderia, Rocche and Trifoglietto; finally, the Stratovolcano Supersynthem was characterized by an intense effusive and explosive activity of the Ellittico volcano since 57 ka and then by a mostly effusive activity that built the Mongibello volcano from 15 ka.