LATE QUATERNARY DEFORMATION IN THE CATANIA URBAN AREA (EASTERN SICILY): RELATION WITH THE ACTIVE TECTONICS G. Tortorici, F. Pavano, G. Romagnoli, S. Catalano

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Introduction. The Catania region is located on the frontal zone of the Sicily collision belt (Fig. 1), along the active Nubia-Eurasia convergent plate boundary. The area is affected by an active NNW-SSE oriented compression that is evidenced by focal mechanisms (Scarfi *et al.*, 2013), stress in situ measurements (Bousquet *et al.*, 1988) and geodetic data (De Guidi *et al.*, 2015). Impressive contractional structures (Monaco *et al.*, 2002, Catalano *et al.*, 2004) affect the Middle Pleistocene marine succession which crops out to the southeast of the town (Fig. 1). A short segment of a N80 trending thrust ramp, which brings Middle Pleistocene sands on 80 ka old alluvial conglomerates, crops out in the southern part of the town (Fig. 2). Moreover, in the Catania alluvial plain, to the southeast of the town, a set of ENE-WSW oriented folds (Fig. 1) caused responses of the river channel morphology of the Simeto River (Catalano *et al.*, 2011). Even if in the urban area of Catania the etnean volcanic cover and the intensive urbanization make it difficult, the recognition of the prolongation of the Late Quaternary contractional tectonics beneath the town is a primary target for assessing the seismic hazard of this densely populated area. In this paper we present new geological data, in order to contribute to a more precise location of the recent contractional features in the substratum of the urban area.

Geological evidence of contractional features in the Catania substratum. The Late Quaternary tectonic features of the Catania area modified a very complex geometry, due to the high tectonic mobility of the area. The geology of Catania is characterized by a sedimentary



Fig. 1 – Geological sketch map of the Catania region, eastern Sicily. Key: (1) Holocene deposits (a) Late Würmian-Holocene alluvial fan (b); (2) Etnean Lavas: recent alkaline products (80 ka to Present) (a); ancient alkaline products (180-100 ka) (b) (chronological data from Gillot *et al.*, 1994); (3) sub-alkaline products of Mt. Etna volcanic district (320-200 ka) (chronological data from Gillot *et al.*, 1994); (4) Middle Pleistocene foredeep deposits and Late Quaternary marine terraces; (5) Undifferentiated Meso-Cenozoic Maghrebian allochthonous units; (6) Pliocene-Early Pleistocene volcanics of the Hyblean Plateau; (7) Meso-Cenozoic foreland sequences of the Hyblean Plateau; (8) Late Quaternary and active tectonics and volcano-tectonics: strike-slip fault (a); normal fault of the "Siculo-Calabrian Rift Zone" (b), thrust (c), anticline (d) dry and eruptive fissure (e); (9) buried front of the Maghrebian allochthonous units; (10) Middle Pleistocene Hyblean extensional fault; (11) main transform fault zone; (12) maximum horizontal extension in the Etnean area and in the Ionian offshore; (13) maximum horizontal compression in the Catania Plain area; (14) main earthquake (a): in the map the major (M≥7) historical earthquakes are reported; the inset also shows the main instrumental events, with available focal mechanisms (b); (15) GPS vector; (16) rift-flank volcanoes (see inset a). The inset a shows the deformation belts connected to the active Nubia-Eurasia convergent boundary and the Siculo-Calabrian Rift Zone respectively. The inset b refers to the relative motion between the plates. (From Catalano *et al.*, 2011 mod.).

substratum composed of a monotonous Early-Middle Pleistocene marly-clay succession, at places capped by few tens of meters of marine sands (Monaco *et al.*, 2000). This marine succession is exposed at the southeastern end of Catania (S. Giorgio in Fig. 2) where it form the SE dipping forelimb of a vast anticline, whose hinge zone is located in the area of Misterbianco (Fig. 2). The sedimentary substratum is severely uplifted and is modelled by a flight of marine terraced coastal clastic wedges, ranging in age from the OIS 7.5 (240 ka) to the OIS 3.1 (40 ka) (Monaco *et al.*, 2000; Catalano *et al.*, 2004). At places, the terraced successions also include the ancient (Middle Pleistocene) lava flows of the earlier activity of Mt. Etna. The terraced slope, which extends in a NE-SW direction from the southern periphery of Catania to the coast of Aci



Fig. 2 - Geological Map of the Catania region (for location see box in Fig. 1).

Castello (Fig. 2), is deeply incised by NW-SE oriented consequent valleys that are completely infilled with the Late Pleistocene-Holocene Etnean lava flows (Monaco *et al.*, 2000).

Catania-Acicastello terraced slope. The terraced slope of the coast from Catania to Aci Castello is the result of the tectonic uplift, since the Late Pleistocene, at the footwall of an active normal fault belt located in the Ionian offshore (Monaco et al., 2002; Catalano et al., 2004; 2008). However, the new collected geological data from the northern part of Catania and the adjacent San Gregorio and Aci Castello areas (Fig. 2) evidenced the primary Middle Pleistocene geometry of the culmination (profile 3 and 4 in Fig. 3; see Fig. 2 for location). Across the coastal slope, impressive fold deformation affects the sedimentary substratum and the Middle Pleistocene lava flows, which are unconformably covered by the Late Pleistocene to Holocene marine terraces and lava flows. A clear flexure affects the marly-clays substratum and the associated submarine tholeiitic lavas, cropping out in the coastal slope of Aci Castello (profile 4 in Fig. 3). In the upper part of the slope, the tholeiitic lavas are interleaved in the marly-clays succession that is gently dipping towards the SE. The lava horizon, on a distance of about 700 m, decreases in elevation from 230 to 100 m a.s.l., forming a gentle asymmetric syncline. The same lava horizons, at the base of the slope, form an antiformal flexure, connecting the levels that crops out at an elevation of about 100 m a.s.l. with those lying along the coast of Aci Castello.

More to the south, the interpretation of the well logs from two boreholes (P1 and P2 in Fig. 2) demonstrates the occurrence of the antiformal flexure also in the area from San Gregorio to Catania (profile 3 in Fig.3; see Fig. 2 for location). In this transect, the upper part of the slope shows the ancient lava flows (140 ka; Branca *et al.*, 2011) that rests on the sands of the OIS 7 marine terrace (240-200 ka), unconformably covering the marly clay substratum. The lower



Fig. 3 - Geological profiles across the Catania region (for location see Fig. 2).

part of the slope is draped by a thin recent volcanic cover, whose attitude still reproduces the staircase subvolcanic morphology, due to the occurrence of the Late Quaternary marine terraces. The boreholes P1 and P2, at the base of the slope, drill the recent (Holocene and Middle Pleistocene) covers, consisting of lava flows and marine sediments, that unconformably cover the marly clays substratum. The boreholes P1 intercepts the tholeiitic lavas at a depth of about 280 m b.s.l., thus confirming the prolongation at depth of the forelimb of the Aci Castello flexure. The borehole P2, at a distance of few tens of meters, does not intercept the tholeiitic lavas at depth, thus suggesting a sharp interruption of the volcanic horizons that we interpret as due to a blind thrust ramp at the leading-edge of the flexure.

At its northern edge, the Catania-Aci Castello coastal slope is bounded by a roughly E-W oriented tectonic alignment, along which the tholeiitic lava flows - that are interfingered with the marly clay horizons - abruptly interrupts. This tectonic alignment, extending from the village of San Gregorio to the coast of Aci Trezza, immediately to the north of Aci Castello (Fig. 2), has been analyzed in detail in the area of San Gregorio (Profile 5 in Fig. 3). In this area, the E-W north-dipping thrust ramp has been recognized. The hanging wall of the surface consists of a culmination of the Middle Pleistocene lavas and the underlying marly clays substratum. The geometry of the hanging wall is partly obscured by younger normal faults that caused the collapse of the original, wide gentle ramp-anticline. In the footwall of the structure, the Middle

Pleistocene (140 ka B.P.) lavas rests on the sands of the of the OIS 7 marine terrace (240-200 ka). The Holocene lava flows seem to conceal the structure. The vertical offset of the Middle Pleistocene lavas reaches about the 110 m.

More to the east (see profile 4) the hanging wall of the ramp consists of a culmination of the lower portion of the marly clays succession that overthrust the top levels, containing the tholeiitic lavas. Surface data are insufficient to estimate the total vertical displacement of the structure.

Discrete portions of the E-W oriented San Gregorio thrust are reactivated by dextral motion due to the accommodation of recent tectonic motions from a series of NW-SE oriented normal faults, affecting the southern flank of Mt. Etna. The reactivated segments show evidence of active motion, mostly due to aseismic creeping.

Catania Old Town thrust. In the southern sector of the Catania town (Fig. 2), a N80, NNWdipping thrust ramp was temporarily exposed in an excavation front of a quarry. The hanging wall of the thrust consists of an asymmetric anticline deforming Middle Pleistocene sands. These levels ramp over the alluvial deposits referred to the 80 ka terrace (Monaco et al., 2000) that show an almost horizontal attitude. The elevation of the base of the 80 ka conglomerates of the hanging wall suggests more than 10 m of vertical offset. More to the east, a geological section (1 in Fig. 3) based on several boreholes data, images the possible prolongation of the structure, just beneath downtown. The geometry of the ramp is partially obscured by the occurrence of a paleo-valley, which is infilled with lava flows and the associated alluvial deposits. The buried valley undercuts the terraced marine deposits of the OIS 3.3 (60 ka) (Monaco et al., 2000) and it is deeply entrenched within the Middle Pleistocene marly clays substratum. The depth of the valley axis (36 m b.s.l.), corrected for the mean vertical uplift rate estimated in the Catania region at 1.2-1.3 mm/a (Monaco et al., 2002), constrains the river incision at about 50 ky B.P., when the base level was 80 m below than the present one. This estimation is consistent with the presence of Plagioclase-rich lava flows within the valley, which are typical of the etnean activity between 56 to 15 ky B.P. (Volcano Ellittico; Branca et al., 2011). On the two sides of the valley, a different attitude and elevation of the 60 ka-old marine terraced deposits (OIS 3.3; Monaco et al., 2000) can be appreciated. In the southern flank of the valley, the marine terrace is gently dipping towards the south and the basal abrasion surface rests at an elevation of about 5 m a.s.l.. Across the valley, the basal surface of the marine terrace is vertically displaced for about 20 m and is markedly dipping to the north. Within the valley, a sharp discontinuity of the lava and alluvial horizons is compatible with the occurrence of a N-dipping ramp, coherent with the deformation of the morphological horizons on the two sides of the valley.

The extension of the fault trace towards the Ionian coast is undetermined. The absence of any evidence of the thrust along the E-W oriented geological Profile 2 (Fig. 3) suggests to extend the ramp to the south of the trace of the geological section.

Discussion and conclusions. The new geological data collected in the town of Catania provide precious information to identify Late Quaternary contractional tectonics. These consist in the continuation of the main Middle Pleistocene and Late Pleistocene tectonic features that are widely exposed to the south of the city. However the active tectonic picture deriving from the inversion of geodetic data (De Guidi *et al.*, 2015) and by seismic investigation (Gross *et al.*, 2016) shows a precise relation with the distribution of these tectonic features, along which impressive surface deformation is still now cumulating.

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