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THE INVOLVING OF THE PLIOCENE-PLEISTOCENE SUCCESSION IN THE T. TRAVERSOLA DEFORMATION ZONE (NW ITALY)

Marco Gattiglio[1], M. Gabriella Forno[1-2], Cesare Comina[1], Alfredo Doglione[1], Donata Violanti[1], Diego Barbero[1]

[1] Earth Science Department, Università di Torino, Torino, Italy
[2] NatRisk Interdipartimental Centre, *Università di* Torino, Grugliasco, Italy
Corresponding author: C. Comina<cesare.comina@unito.it>

ABSTRACT: The N-S trending T. Traversola Deformation Zone (TTDZ), developing on the western edge of the Asti Reliefs, represents one of the most relevant geological features of the Piedmont hilly area, in northwestern Italy. Morphologically this deformation zone corresponds to an evident scarp with, a rectilinear trend in map view, an height up to a hundred meters and a length of about 30 km, delimiting a hilly area (Asti Reliefs) from a plain area (Poirino Plateau) developed at averagely higher altitudes.
In the western side of the Asti Reliefs some local differences between the "villafranchian succession" (Pliocene-Pleistocene) occur across the scarp, together with soft sediment deformations. Close to TTDZ the sediments (Piacenzian and Calabrian) are also widely fractured and locally show cataclastic structure. New morphological, stratigraphic, micro-palontological, structural and geophysical data reported in this study better highlight how the TTDZ is structurally organized in several N-S trending, sub-vertical right faults with horizontal displacement. In the southern slope of the Turin Hill the deformation zone probably continues in the Moncucco Torinese quarry area where it strongly deforms the Messinian sediments.
The TTDZ represents the shallow evidence of a deep right structure that separates the Poirino Plateau, showing a significant northward shift, from the Asti Reliefs, where such a shift is less evident. This structure exhibits different deformation magnitude in sediments of different age, suggesting that the tectonic activity took place throughout a long time during post-Messinian periods. The TTDZ could be also interpreted as part of a structural context related to north-thrusting of the Piedmont Hills over the Po foreland basin.

KEYWORDS: T. Traversola Deformation Zone, tectonics, Piedmont hills, Electric Resistivity Tomography

1. INTRODUCTION AND GEOLOGICAL SETTING

This research work regarded two sectors (1 and 2 in Fig. 1) located in the central Piedmont hilly region (NW Italy), where different morphological aspects, plain and reliefs respectively, occur from west to east.

In the western side of the Asti Reliefs (sector 1 in Fig. 1) the sedimentary succession is defined by shelf sandy deposits (Asti Sand), referred to the Zanclean, deltaic deposits ("villafranchian" Lower Complex) and fluvial deposits ("villafranchian" Upper Complex) separated by the Cascina Viarengo unconformity (Carraro, 1996). The two complexes are referred to the Piacenzian and Calabrian respectively (Dela Pierre et al., 2003; Forno et al., 2015). Above these sediments a widespread silty and locally gravelly fluvial cover of middle and upper Pleistocene occurs. These fluvial deposits are linked to the Po and Tanaro rivers ancient courses (3, 4 and 5 in Fig. 2) (Forno, 1982). The whole sedimentary sequence is deformed by the Asti Syncline that consists in a wide E-W regional scale fold developed in the central hilly area (Poirino Plateau, Asti Reliefs and Alessandria Plateau) (Boni et al., 1970; Carraro et al., 1995) (Fig. 1). The axis of this structure is difficult to locate for its different configuration assumed in the time with different locations for the deformed "villafranchian succession" and middle-upper Pleistocene fluvial cover (Boni et al., 1970; Bigi et al., 1990; Michetti et al., 2012).

In the southern slope of the Turin Hill (sector 2) the sedimentary succession mainly consists of Messinian sediments (Fig 1). These are represented by marine sediments and shallow-water primary evaporites, unconformably covered by reworked gypsum deposits and brackish-water to continental sediments (Irace, 2004) (see Fig. 5). They are overlain by the Zanclean deep marine deposits. The Messinian succession, gently dipping toward south, displays a severe disruption, due to the occurrence of NNW-SSE striking transpressive faults systems, whose activity was related to intra-Messinian tectonics (Dela Pierre et al., 2007). Festa et al. (2009) evidenced that also the Zanclean sediments appear segmented by sub-vertical faults, nearly N-S oriented, suggesting a possible reactivation of the transpressive fault systems.

In both the sectors the sedimentary succession is cut by a major N-S trending morphological scarp elongated for about 30 km and with height up to a hundred meters (Fig. 2). This scarp is one of the most representative elements of the entire hilly area. Several authors provided different descriptions and interpretations about the origin of this scarp. In the oldest geological literature (Castiglioni B., 1934; Sacco, 1917) it was referred exclusively to erosional phenomena produced by the tributaries of the Tanaro River, resulting from the deepening of the main watercourse in the uppermost Pleistocene and Holocene (Fig. 2). The middle and upper Pleistocene deposits outcropping at different elevation on the two sides of the scarp have been related to the vertical displacement of a flexure structure type by Forno (1982) and Carraro & Valpreda (1991).

More recently, in the north side of sector 1 the scarp has been interpreted as a major structural discon-

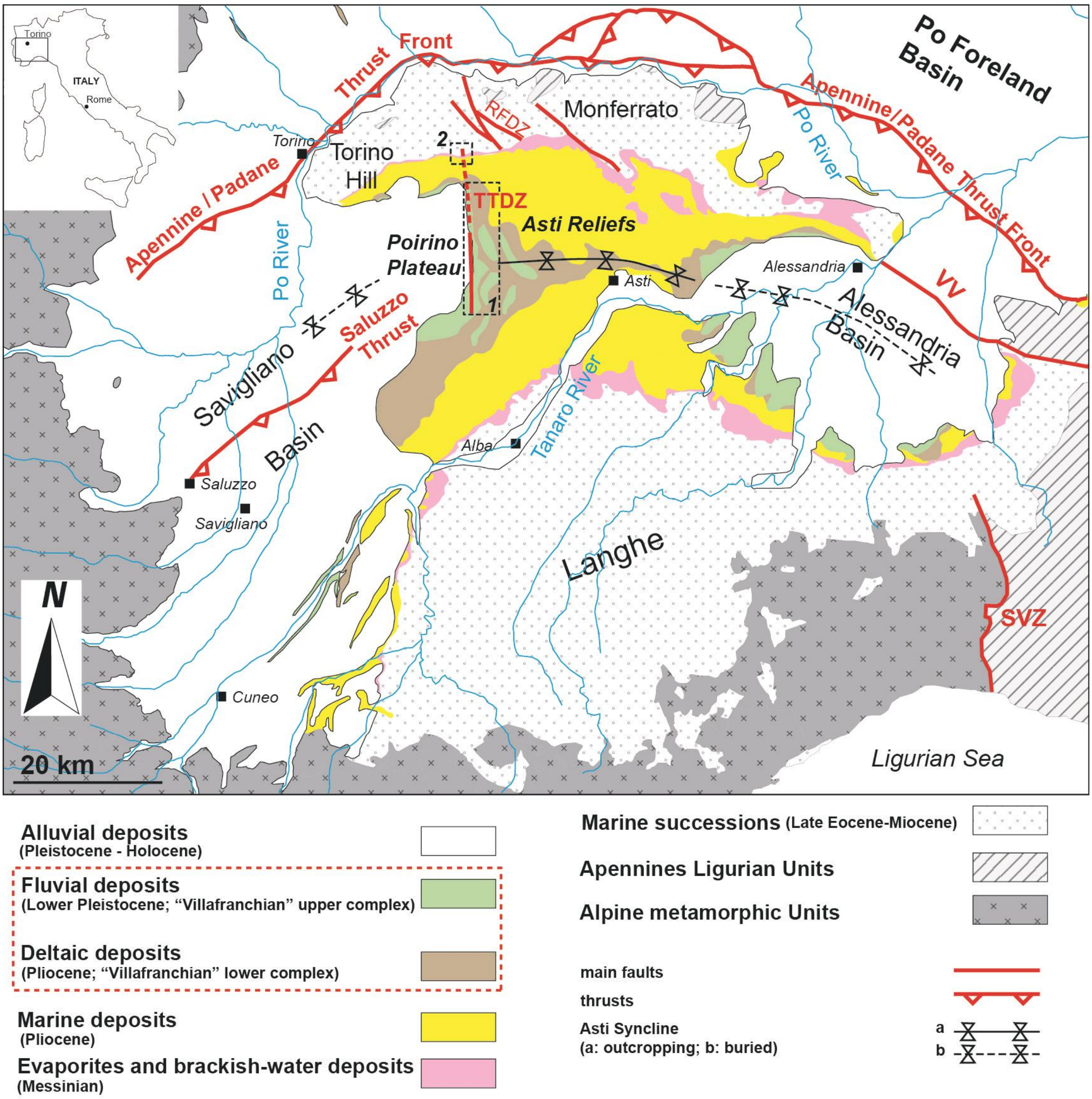

Fig. 1 - Schematic geologic map of the Piedmont hilly region. RFDZ: Rio Freddo Deformation Zone; TTDZ: Torrente Traversola Deformation Zone; VV: Villalvernia Varzi Fault; SVZ: Sestri Voltaggio Zone. The dotted lines represent the sectors of the research (1 and 2) (modified from Forno et al., 2015).

tinuity, e.g. a deformation zone with prevalent horizontal displacement named T. Traversola Deformation Zone (TTDZ) involving the sedimentary succession of the Villafranca d'Asti type-area (Fig. 1) (Carraro et al., 1995; Carraro, 1996; Boano & Forno, 1999; Doglione, 2011).

Structures (lineaments and faults) of recent age (Pliocene and Pleistocene), N-S trending, have been also observed in the Monferrato, even if they are not very common. Dela Pierre et al. (2003) justified the paucity of these structures considering that they are located in an area characterized by few outcrops and many faults and folds with different directions.

Particularly, in the Trino area (north of Monferrato) a N-S structure (fault or flexure) has been reported by Giraudi (2014) and named Salera Line. Northward, this line interferes with the Appennine/Padane Thrust Front and is responsible for differences between the stratigraphic succession on both sides of the line, allowing the lifting of the western area. The movement described along the Salera Line is connected to oblique deformations or different activity over time. Southwards, this structure is testified by a strong tectonic deformation affecting the Monferrato marine succession (Giraudi, 2014).

In this paper we present new data, deriving from a still in progress multidisciplinary research, which is focused on the TTDZ, a regional brittle deformation system evidenced by the morphological scarp (Fig. 3). Detailed geological surveys and multidisciplinary methodologies such as geophysical, structural, morphological, pedological and micro-paleontological analyses have been undertaken along the N-S deformation zone (Fig. 2). These surveys are also aimed to highlight the possible extension of the deformation zone along the whole scarp (sector 1) and northwards up to the southern slope of the Turin Hill (sector 2).

2. METHODS

In the investigated sectors detailed geological surveys and descriptions of the morphological features have been carried out. The various fracture systems and fault surfaces have been measured, also determining their direction of movement. The difficulties encountered in the field work, related also to the scarcity of outcrops, suggested to integrate the field observations with other analyses.

Many micro-core hand drilling, up to 2 meters deep, along the whole defor-

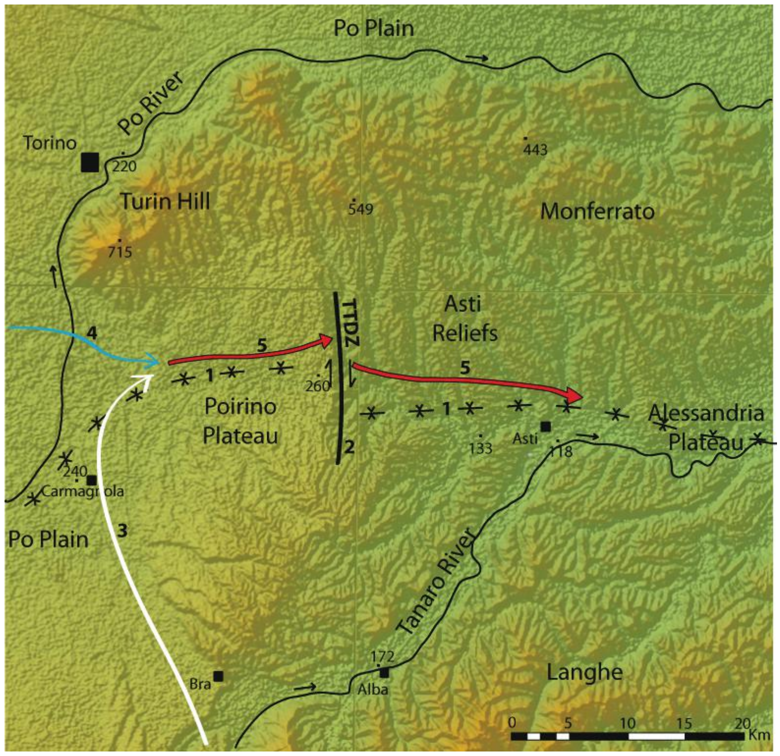

Fig. 2 - Aster Global DEM (NASA-MITI, Dic. 2009) of the Piedmont hilly region. 1) Asti Syncline axis; 2) TTDZ: T. Traversola Deformation Zone; 3) upper Pleistocene ancient course of the Tanaro River; 4) upper Pleistocene ancient course of the Po River; 5) upper Pleistocene ancient course of the confluent Po and Tanaro rivers.

Fig. 3 - Overview of the scarp delimiting the Poirino Plateau in the background (260 m) from the Asti Reliefs in the foreground (240 m).

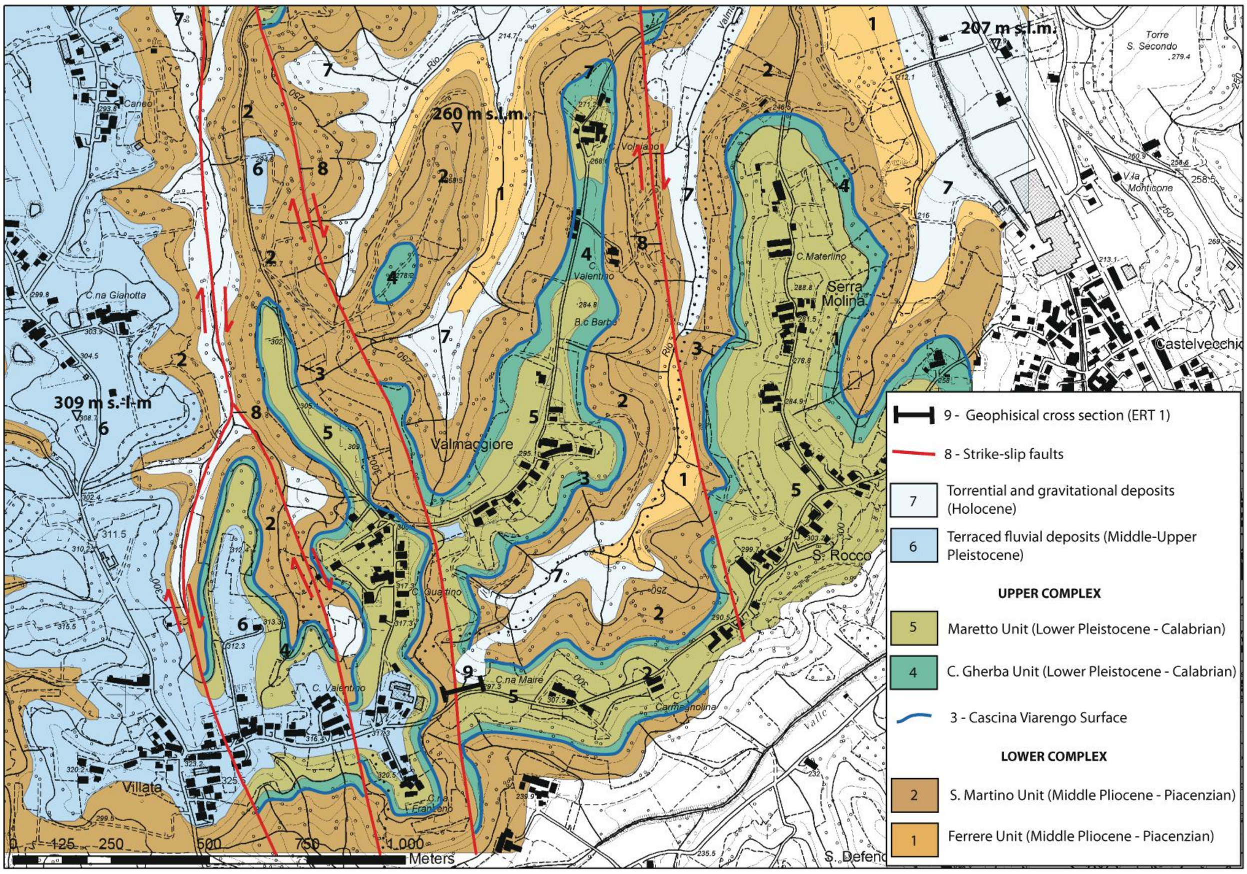

Fig. 4 - Detailed geological map of the southern stretch of sector 1 in Fig. 1. The location of the geophysical cross section ERT 1 near the Villata village is reported. The N-S faults are connected to the TTDZ.

mation zone were performed. These observations permitted to identify the facies of the sedimentary succession underlying an uniform cover of colluvial deposits. The gathered data allowed mapping the succession involved in the deformation at the scale 1:10,000; an example of the results is reported in the detailed map of Fig. 4.

Furthermore an exploratory trench has been executed in the sector 2 (southern slope of the Turin Hill) into the Moncucco Torinese quarry (see Fig. 5). This trench (1.5 to 3.5 meters deep and about 10 meters long), parallel to the strike of the deformation zone, evinced the brittle deformation involving the Messinian deposits.

From the same trench 38 samples for micropaleontological analyses have been collected. Foraminiferal analyses have been carried out on sieving residues>250 μm, 125-250 μm and 125-63 μm, prepared following standard techniques (Haynes, 1981; Violanti, 2012). Taxonomy is according to Tjalsma (1971), Kennet & Srinivasan (1983) and Iaccarino (1985).

Two different electrical resistivity surveys (ERT 1 and ERT 2) have been also executed, in sector 1 (Villata in Fig. 4) and 2 (Moncucco Torinese quarry in Fig. 5) respectively. Both surveys, approximately E-W oriented namely perpendicular to the deformation zone, are aimed to confirm the location of the structures supposed by geological field work. The geophysical acquisitions were performed by means of a Syscal-R1 tomograph (IRIS Instruments) with 48 measuring electrodes and 5 m spacing for ERT 1 (total legnth of 235 m) and 72 measuring electrodes and 1 m spacing for ERT 2 (total length of 71 m). A Wenner-Schlumberger measuring sequence was used for the two acquisitions in order to obtain both vertical and lateral resolution. Acquired data were processed by the commercial inversion code Res2Dinv® (Loke & Barker, 1996). A good convergence of the results has been obtained in both the inversions with RMS errors below 2 % in ERT 1 and below 4 % in ERT 2.

3. STRATIGRAPHIC AND STRUCTURAL FEATURES OF THE T. TRAVERSOLA DEFORMATION ZONE

In plan view, the examined scarp, very articulated in morphological details, shows a generally rectilinear N-S trend (Fig. 1 and Fig. 2). This scarp sharply divides a plain area (Poirino Plateau with altitude between 230 and 325 m) by a hilly area essentially developed at much lower altitudes (Asti Reliefs with altitude between 130 and 320 m) (Fig. 3).

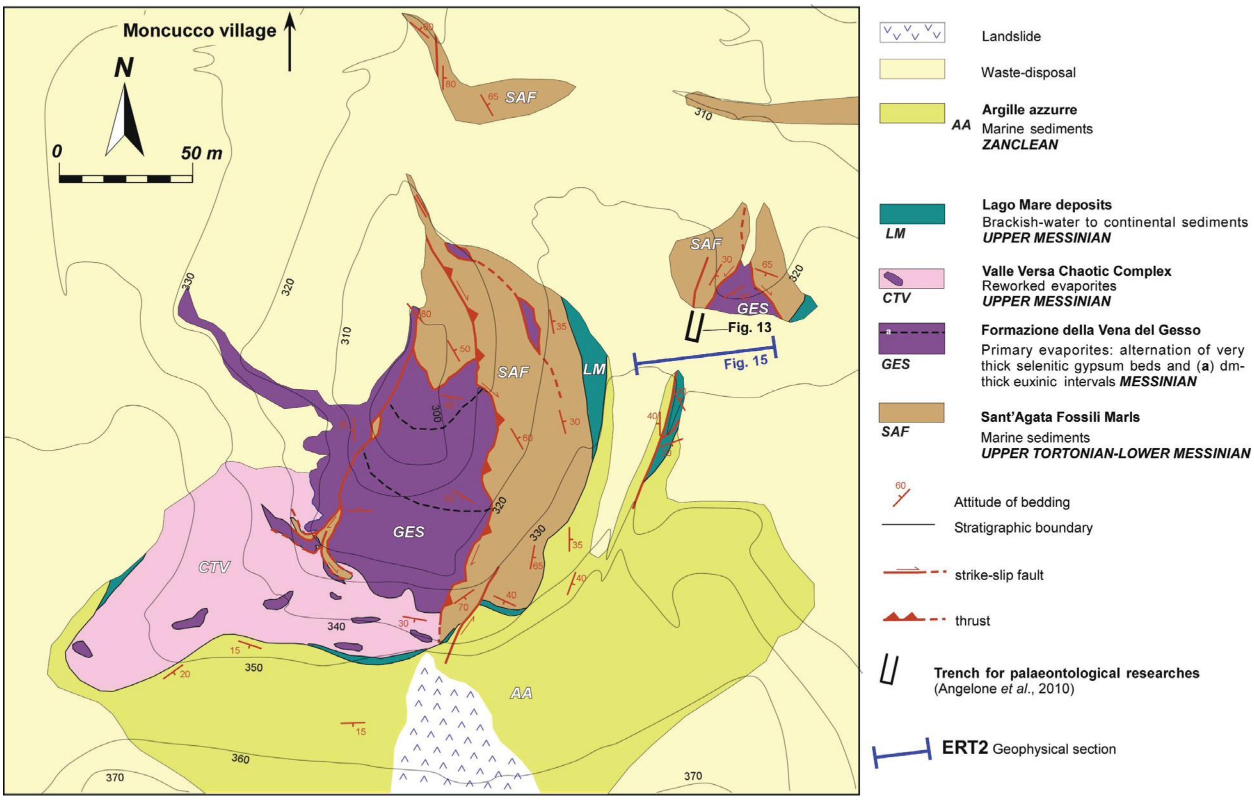

Fig. 5 - Detailed geological map of the sector 2 in Fig. 1 including the Moncucco Torinese quarry. The N-S faults are probably related to the T. Traversola Deformation Zone. The location of the geophysical cross section ERT 2 and the manmade trench are also reported (modified from Irace, 2004).

The deformation of the Pliocene-Pleistocene succession of sector 1

The Pliocene-Pleistocene succession ("villafranchian" Lower Complex and Upper Complex) is well exposed in the western sector of the Asti Reliefs (sector 1). The geological surveys allowed to locally recognize tens of meters height differences between the succession outcropping on the two sides of the scarp (Fig. 4).

These differences are related to the presence of several N-S trending sub-vertical brittle structures (Fig. 6) characterized by prevalent dextral strike-slip displacement. Along the scarp, pervasively fractured areas, giving rise to cataclastic sediments, are observed in the surroundings of N-S trending faults (Fig. 7). In these areas, mesoscopic "scaly fabric" structures (sensu Vannucchi et al., 2003) (Fig. 8), essentially with N-S trends, are characterized by anastomosing polished and slickenlines surfaces.

The slickenlines show low dip values and S-C geometry of the polished surfaces, confirming the dextral strike-slip displacement. The presence of brittle sediment deformations confirms that the displacement not only took place along the main fault surfaces but is also distributed in numerous less important movement surfaces ("C" planes) widespread along deformation bands and confined close to the major faults (Fig. 9).

Sediments in the deformation bands are also characterized by carbonate distributed along dense networks of cracks (Fig. 10) or concentrated in concretions, both N-S trending and sub-vertically dipping, parallel to the major faults (Fig. 11). Reworked bodies are locally present in these bands, also affected by cataclastic deformation. Decimetric thick gravelly bodies are observed, characterized by vertical dip, or centimetric fragments of silty bodies iso-oriented along the minor brittle structures. Locally, gravity-induced syn-sedimentary deformations of sediments are also observed, associated to fractures and faults. In detail, some soft sediments deformations are observed, as slumping and de-structuring of the primary laminations, or chaotic structure connected with the overall reworking of the sediments along the main faults (Boano et al., 1997).

Fractures and normal faults trending N50°E (Serra Fault, Capriglio Fault) and N120°E (Castelnuovo Fault Zone, C. Fagliaverde Fault Zone) also affect the villafranchian succession (Fig. 12). Near Buttigliera d'Asti the Castelnuovo Fault Zone appears shifted southwards along the eastern side of the TTDZ with respect to its location in the western side (Fig. 12).

The deformation of the Messinian succession of sector 2

The TTDZ probably extends northwards at the southern limb of the Turin Hill, where the upper Messinian succession appears strongly deformed. In the Moncucco Torinese quarry (Fig. 5) a N-S oriented trench for

Fig. 6 - N-S oriented fracture system in the S. Martino Unit silt near C. Quartino (NE of Villata village) connected to the T. Traversola Deformation Zone.

Fig. 7 - The S. Martino silt are locally pervasively fractured similarly to cataclastic rocks (locality near C. Quartino) along the T. Traversola Deformation Zone.

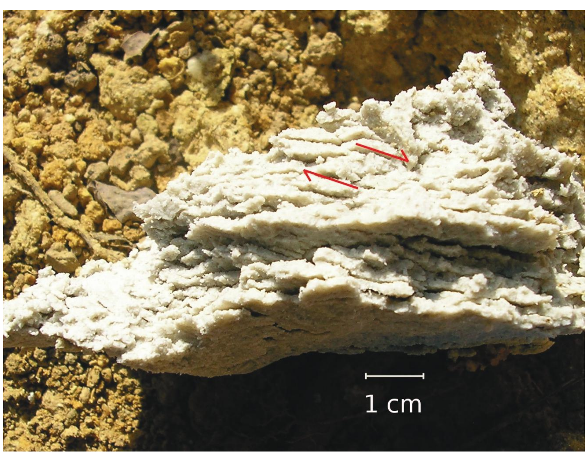

Fig. 8 - The S. Martino Unit silt often shows scaly fabric structure along the T. Traversola Deformation Zone. The sample collected indicates a N-S dextral strike-slip fault near the Valfenera village.

Fig. 9 - Pervasive N-S oriented fractures in the S. Martino Unit silt SE of Valfenera Village, referred to the T. Traversola Deformation Zone.

Fig. 10 - Distribution of carbonate along a dense network of mineralized fractures along the major N-S faults defining the T. Traversola Deformation Zone (south of Valfenera village).

Fig. 11 - Large carbonate concretions with vertical arrangement according to the N-S fractures trend forming the T. Traversola Deformation Zone (south of Valfenera village).

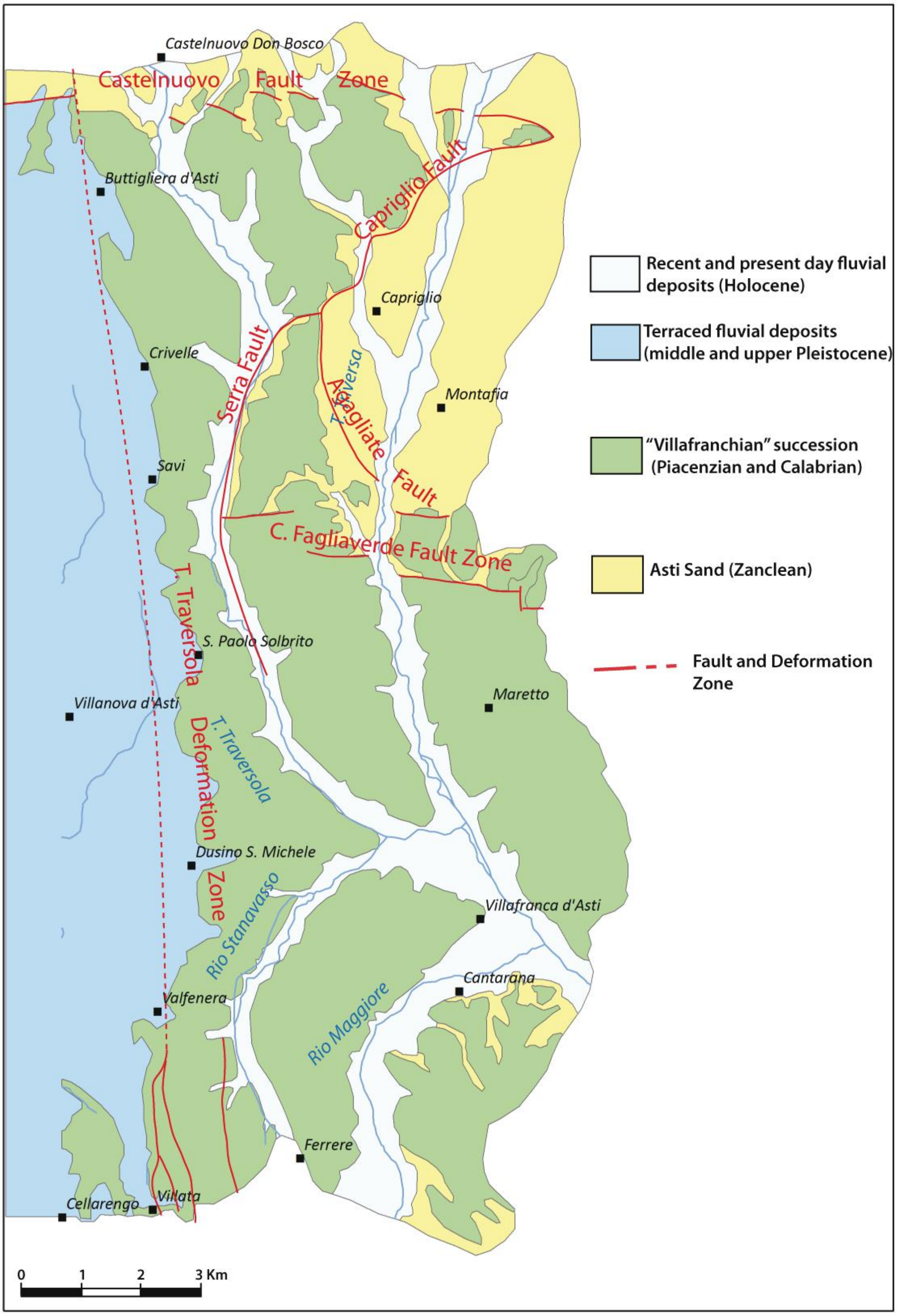

Fig. 12 - The main faults and deformation zones involving the stratigraphic succession of the western Asti Reliefs (sector 1 in Fig 1).

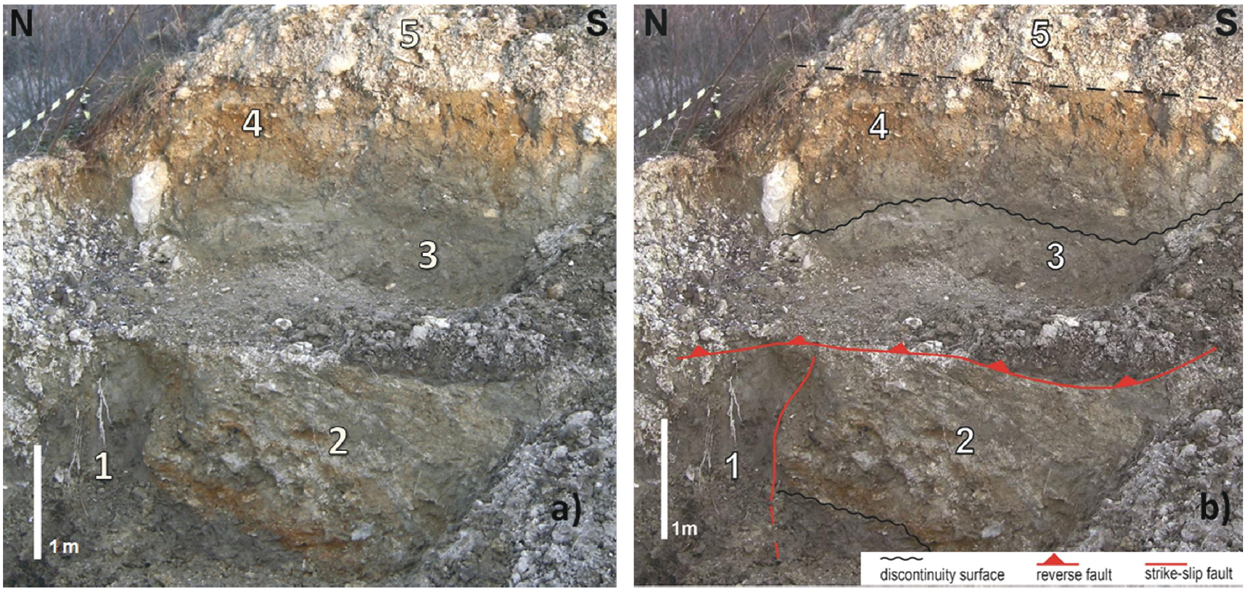

Fig. 13 - Eastern wall (a) and interpretation (b) of the N-S oriented trench in the Moncucco Torinese quarry. The continental sediments (1 and 3) are unconformably covered by filling deposits (2 and 4) and involved by a strike-slip and a reverse fault. An anthropic cover is observed on the top (5).

paleontological researches was recently excavated and the two eastern overlapping walls observed (Angelone et al., 2010). In detail, in the lower wall clay, sandy silt and minor gravel lenses connected to a continental environment are visible (1 in Fig. 13). These sediments are cut by a concave articulated discontinuity on which a gravelly and sandy sequence inclined towards south occurs, probably forming a reworked body (2 in Fig. 13).

The upper wall shows sub-horizontal massive to weakly laminated sand and silt, also likely referred to the continental environment (3 in Fig. 13). Also these sediments are cut by an articulated discontinuity on which a set of coarse-grained sharp-sided dikes occurs (4 in Fig. 13). These dikes, made up of massive gravelly -sand, deform the laminated layers in the host-rock. In the top of the upper wall an anthropic cover is present (5 in Fig. 13).

The sediments are dissected by faults and minor joints. A N-S striking sub-vertical transcurrent fault occurs in the lower wall. The deposits (1 in Fig. 13) are locally verticalised and show an intense stratal disruption, related to the development of this fault. A reverse fault, marked by a major clayey polished and slickensided surface, also involves the sediments in the lower wall, separating the bodies 2 and 3.

The sediments below the two discontinuities (bodies 1 and 3) appear lithified, suggesting a strong lithostatic load. These sediments, only deformed, are in site and referred to the Messinian succession. The bodies above the discontinuities (bodies 2 and 4) are soft, suggesting a low lithostatic load. This evidence suggests a syn-sedimentary deformation younger than those affecting the underlying Messinian sediments. The upper sediments (bodies 2 and 4) are probably referred to reworking phenomena involving sediments of various facies, and possibly of various ages, fillings of depressions essentially along the N-S structure. In this picture the reverse fault probably doubles the stratigraphic succession defined by Messinian sediments discontinuously covered by fillings.

Micro-paleontological analyses confirm a sediment pattern more complex than previously reported. Brackish assemblages of the upper Messinian lagomare facies, with molluscs, ostracods and rare foraminifers (*Ammonia tepida*), locally occur. Most of the sediments cut by the trench yield very abundant planktonic foraminifera of older Miocene intervals. Assemblages of Tortonian age are dominant, documented by rather common *Globorotalia suterae* and *Gt. menardii* form 4 of Tjalsma (1971). Lower Messinian species, such as *Gt. miotumida* and *Gt. conomiozea*, seldom occur. Studies are in progress to better delineate the biostratigraphical and palaeoenvironmental interpretation of the succession and verify the possible presence of Pliocene deposits involved in the deformation.

Even if a chronological attribution is still uncertain, these soft-sediment deformations involving the Messinian and perhaps Pliocene succession in the sector 2 could be likely correlated to similar features recognized within the sediments of “villafranchian” Lower Complex (Piacenzian) in sector 1. In this perspective, the structural framework recognized in the Moncucco Torinese area could be considered as the evidence of the northwards prolongation of the TTDZ. The magnitude difference in the deformation, between the bodies below and above the two unconformities in the two walls of the trench, based on these assumptions, suggests a long-lasting tectonic activity since Messinian, throughout the Pliocene.

The deformation of the middle-upper Pleistocene succession

The silty and locally gravelly fluvial deposits related to the middle and upper Pleistocene have different distribution on the Poirino Plateau in respect to the Asti Reliefs. These sediments constitute a continuous cover in the Poirino Plateau with a thickness between a few meters and few tens of meters. On the contrary, they form, a series of thin bodies in the Asti Reliefs allow on top of the ridges or infilling large meander depressions (Forno, 1982; Dela Pierre et al., 2003).

The middle and upper Pleistocene sediments overall form E-W trending bodies connected to old watercourses. The petrographic and mineralogical association of fluvial sediments permit to refer these sediments to the paleo-Po and paleo-Tanaro rivers. These rivers in the middle Pleistocene shaped two distinct bands (see 3a and 3b in Fig. 17) subsequent confluent into a single collector during the upper Pleistocene (see 4 in Fig. 17). More recently the Po and Tanaro rivers have been affected by remarkable diversion river phenomena (Carraro et al., 1995). Their current courses, outflowing to the NW at the northern edge of the Turin Hill for the Po River and within the Asti Reliefs for the Tanaro River, develop in the uppermost Pleistocene.

4. GEOPHISICAL SURVEYS

Objective of the surveys was the identification in depth of the presence of incoherent sediments, that can be associated to the TTDZ, and differences in the stratigraphic sequence on the two sides of the deformation zone.

The reconstructed resistivity section in the Asti Reliefs near Villata (Fig. 14, ERT 1 in Fig. 4 with E-W trend perpendicular to TTDZ) shows sediments with different electric resistivity. The presence of a shallow cover (about 5-6 meters) of relatively conductive sediments (resistivities below 15 Ohm.m) associable with silty-clay sediments (referred to the Maretto Unit) is observed in the central and eastern sectors of the section overlying a more resistive (above 400 Ohm.m) formation associable with the presence of gravel and sand (referred to the Gherba Unit) (both units are referred in Fig. 4). The western continuity of this succession is however cut by a zone characterized by lower resistivity evident between progressive 40 and 60 m (dotted lines in Fig. 14). This zone likely represents a fractured zone well comparable with the map location of a fault connected to the TTDZ (Fig. 4).

The reconstructed resistivity section in the southern slope of the Turin Hill near Moncucco Torinese (Fig. 15, ERT 2 in Fig. 5 with trend perpendicular to the section shown in Fig. 13) shows a high lateral variability in the resistivities. The more resistive anomaly of this section (200 Ohm.m in the ENE side of the section) is well comparable with gypsum location in the quarry. Two low resistivity zones (5-15 Ohm.m) probably associable to clay, silt or sand are evident in the center of the image, vertically separated by a more resistive formation (about 80 Ohm.m) potentially correlated to a gravel lens. These low resistivity zones are compatible with sediments involved by N-S oriented fault systems observed in the trench realized for paleontological researches.

5. INTERPRETATION OF THE T. TRAVERSOLA DEFORMATION ZONE

The data collected allows us to read the whole scarp separating the Poirino Plateau from the Asti Reliefs as the morphologic evidence of an important brittle structure already known in the northern stretch of the sector 1 as the TTDZ (Carraro, 1996). Its geological significance is of complex reading due to the mutual relation between sedimentary succession and deformation development.

In the present work, still in progress, this structure has been recognized up to the southern slope of the Turin Hill. At map scale, this deformation zone is highlighted by a N-S fault systems that cause intense fracturing of the rocks as can be inferred by geophysical cross sections.

Along the deformation zone the villafranchian succession is affected by horizontal displacement (Fig. 16). Generally, a structure with predominant horizontal displacement, involving a sub-horizontal sequence represents a tectonic element difficult to be identified. In this case, the structure may become evident only in areas where the horizontal displacement affects either dipping strata (along the limbs of the syncline in Fig. 16) or sediments affected by previous faults (i.e. shifting of the Castelnuovo Don Bosco Fault in Fig. 12). Only in these two cases the poorly evident horizontal displacement along the fault is also responsible of more evident vertical stratigraphic differences also without vertical displacement.

This structure is also responsible for the different location of the axis of the Asti Syncline in the Poirino Plateau (where the axis is shifted northward) in respect to the Asti Reliefs .

The involving of middle and upper Pleistocene fluvial deposits in the TTDZ is also suggested by several evidence.

For this reason, the TTDZ became apparent only in the marginal areas (Asti Syncline limbs), while in the wide hinge area (Asti Syncline axis), where succession exhibits horizontal arrangement, the displacement is poorly evidenced (Fig. 16).

The middle Pleistocene fluvial sediments related to the ancient courses of Po and Tanaro rivers (Fig. 17) are variously located along the Asti Syncline limbs (southern and northern distributions of sediment relicts related to Tanaro and Po rivers, respectively) in both Poirino Plateau and Asti Reliefs. They appear horizontally shifted, showing height differences (of approximately 25 m) at the two sides of the TTDZ, also in this case not related to a vertical shifting.

The upper Pleistocene fluvial sediments connected to the Po and Tanaro confluent rivers are located in the hinge area in the Poirino Plateau, where they form a wide cover (Forno, 1982). On the contrary, in the Asti Reliefs these sediments only locally occur and are located along the northern syncline limb, where they discontinuously infill the incisions connected to the progressively deepening of the watercourse (Carraro et al., 1995). The location of the river in the limb of the syncline

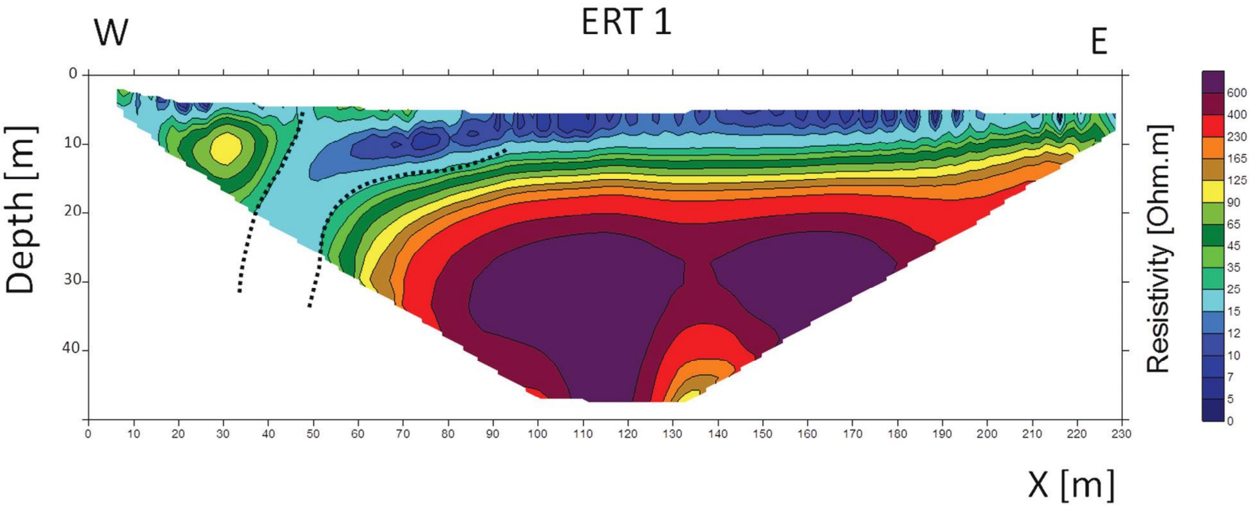

Fig. 14 - Reconstructed resistivity section along ERT 1 near Villata in the sector 1 along the T. Traversola Deformation Zone as located in Fig. 4. The presence of a low resistivity zone (fractured zone) is evidenced by dotted lines in the west side of the tomography

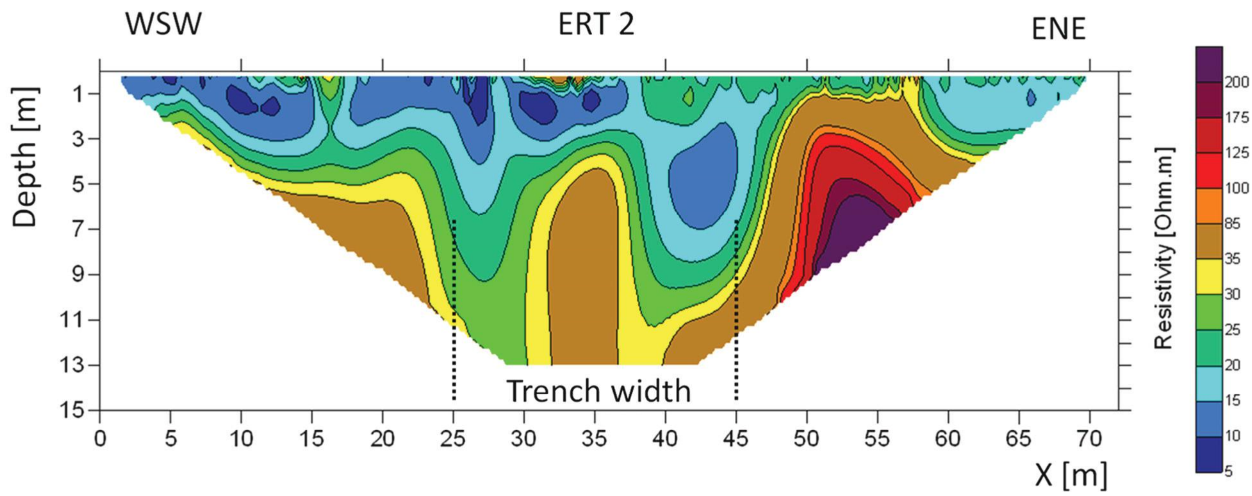

Fig. 15 - Reconstructed resistivity section along ERT 2 near Moncucco Torinese in the sector 2 as located in Fig. 5. Low resistivity anomalies observed in the exploratory trench. Evidence of the area interested by the excavated trench is also reported.

is interpreted as responsible of its abrupt migration towards south in the Asti Reliefs.

The different sediment distribution between the Poirino Plateau and the Asti Reliefs is therefore related to the horizontal displacement along the N-S structure, joining two distinct areas previously not adjacent. The morphological scarp is partly connected to the presence of the deformation zone and partly to the erosion of the tributaries of the Tanaro River.

The TTDZ exhibits different deformation magnitudes in sediments of different age. The continental Miocene sediments outcropping at Moncucco Torinese (sector 2) are strongly deformed in a relatively deep environment. Instead, the fillings above the two unconformities are deformed in a relatively shallow environment. The sediments of the "villafranchian" succession Lower Complex, outcropping at the western edge of the Asti Reliefs (sector 1) also shows soft sediment deformations and faults developed at shallow environment. The distribution of the middle and upper Pleistocene sediments, connected both to the progressive migration of watercourses towards the axis of the growing syncline and to the displacement along the TTDZ, proves a further evolution of this structure.

These observations are consistent with a long time activity of the deformation zone which was tectonically active during the deposition of the Messinian and Pliocene succession and continued in more recent times, as testified by the minor displacement of middle and upper Pleistocene fluvial deposits.

In the regional geological context the TTDZ represents the shallow evidence of a deeper structure, sub-parallel to the Rio Freddo Deformation Zone (Piana & Polino, 1995), but more recently developed. The TTDZ allows to kinematically separate the Poirino Plateau, showing a significant northwards shift, by the Asti

Reliefs area, where the northwards shift is less important.

The TTDZ is not an isolated case. North of the Monferrato Hill the Salera Line exhibits similar trend and apparently similar sense of shear (Giraudi, 2014). Both of these structures involve the Miocene and Pliocene succession indicating a Tertiary activity. They also probably deform the quaternary deposits indicating a prolongation of the tectonic activity in the recent time.

The TTDZ prolongation in the northern slope of the Turin Hill and its relationships with the Appennine-Padane Thrust Front are not yet known at present. Because the Salera Line is associated to the Appennine-Padane Thrust Front we could hipotyze that also the TTDZ could be connected with the development of the same frontal thrust. Therefore, T. Traversola Deformation Zone and Salera Line could be interpreted as part of a structural context related to north-thrusting of the Piedmont Hills over the Po foreland basin.

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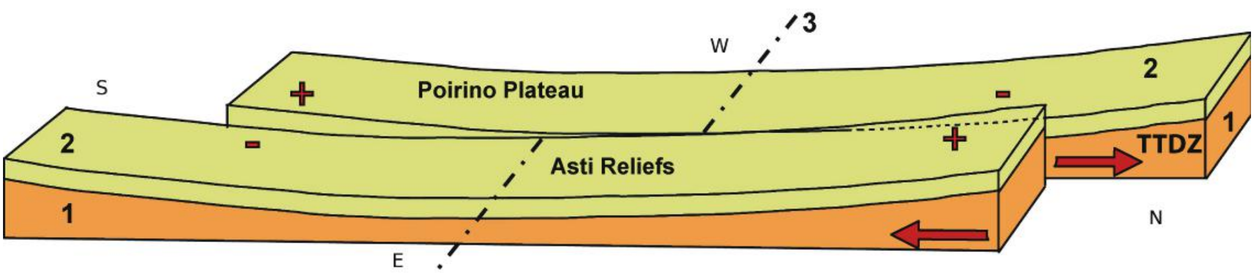

Fig. 16 - Not to scale pattern of the villafranchian succession shifted along the T. Traversola Deformation Zone (TTDZ). 1) villafranchian Lower Complex (Piacenzian); 2) villafranchian Upper Complex (Calabrian); 3) Asti Syncline axis during the Calabrian.

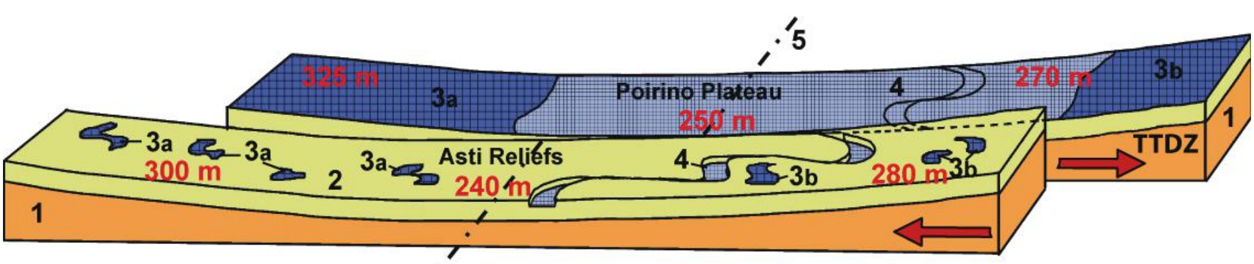

Fig. 17 - Not to scale pattern of middle-upper Pleistocene fluvial deposits displacement along the T. Traversola Deformation Zone (TTDZ). 1) villafranchian Lower Complex (Piacenzian); 2) villafranchian Upper Complex (Calabrian); 3) middle Pleistocene fluvial deposits: 3a connected to the paleo-Tanaro and 3b connected to the paleo-Po ; 4) upper Pleistocene fluvial deposits; 5) Asti Syncline axis during the middle -upper Pleistocene. The altitude of the top of fluvial sediments is also reported.

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