Available online http://amq.aiqua.it
ISSN (online): 2279-7335

Alpine and Mediterranean Quaternary, Vol. 31 (Quaternary: Past, Present, Future - AIQUA Conference, Florence, 13-14/06/2018), 213 - 216

https://doi.org/10.26382/AIQUA.2018.AIQUAconference

MULTIDISCIPLINARY APPROACH TO RECONSTRUCT THE GEOLOGICAL QUATERNARY EVOLUTION OF THE TORRENTE TRAVERSOLA DEFORMATION ZONE (ASTI RELIEFS, NW ITALY)

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ABSTRACT: The results of geological and geophysical surveys performed in the Asti Reliefs along the Torrente Traversola Deformation Zone (TTDZ), have been reported in this work. The outcropping "villafranchian " succession shows local anomalies within this zone, consisting in sub-vertical geological contacts linked to faults, as well as bodies connected to gravitational reworking of sediments. This setting is due to the recent evolution of faults along the TTDZ system, which is characterised by a main strike-slip movement. Tectonic evolution has been clearly outlined by the combination of Electric Resistivity Tomography and geological interpretation of the anomalies in the stratigraphic succession.

KEYWORDS: "villafranchian" succession, Asti reliefs, Torrente Traversola Deformation Zone, electric resistivity tomography, Pliocene, Quaternary

1. INTRODUCTION

Research on the central Piedmont hilly area (Poirino Plateau, Asti Reliefs and Alessandria Plateau) has been carried out in the last years, with the aim of reconstructing the stratigraphic Pliocene and Quaternary succession and its relations with the evolution of the main tectonic structures. In detail, the sediments outcropping in the Asti Reliefs belong to the "villafranchian" succession of the type-area comprising deltaic deposits (Lower Complex) and fluvial deposits (Upper Complex) (Fig. 1a), which are separated by the Cascina Viarengo unconformity (Carraro, 1996). The two complexes, resting on the shelf sandy deposits (Asti Sand of Zanclean age), are referred to the Piacenzian and Calabrian respectively (Dela Pierre et al., 2003; Forno et al., 2015). Above the "Villafranchian" sediments a widespread silty and locally gravelly fluvial cover of Middle-Upper Pleistocene occurs, which is linked to Po and Tanaro rivers ancient courses.

The whole sedimentary sequence is deformed by the Asti Syncline, which consists of a wide E-W regional -scale fold in the central hilly area (Carraro et al., 1995) (Fig. 1a). The transition between Asti Reliefs and Poirino Plateau corresponds to an evident regional scarp, that represents the morphological expression of the Torrente Traversola Deformation Zone (TTDZ), as reported in the geological literature (Carraro, 1996; Gattiglio et al., 2015) (Fig. 1a). This structure also dislocates the Asti Syncline axis that assumes a different location in the Poirino Plateau respect to the Asti Reliefs (Fig. 1b).

The TTDZ belongs to the Langhe seismic district, a region where no strong earthquake was recorded but a quite frequent microseismicity has been observed. About thirty earthquakes were recorded by INGV in the last decade between 1.0 to 4.1 ML. A multidisciplinary approach based on detailed field, geological, geomorphological and geophysical surveys were performed, to better define the TTDZ significance and evaluate its seismic potential.

2. MATERIAL AND METHODS

A detailed geological survey in the Valmaggiore sector, developed along the TTDZ fault system, was carried out (Carraro, 1996; Gattiglio et al., 2015) (Fig. 1b). Anomalies in the stratigraphic succession (soft sediment deformations and gravitational reworked bodies) as well as sub-vertical contacts, both probably connected to the evolutions of faults, were particularly investigated. A geomorphological analysis was also performed, regarding a possible connection between the river trend and the tectonic evolution of faults.

An Electric Resistivity Tomography (ERT) was carried out along a survey line, where a sub-vertical geological contact has been identified, finalized to recognize and/or to confirm the presence of faults (Fig. 2). The ERT was executed by means of a Syscal-Pro tomograph (IRIS Instruments) with 72 measuring electrodes at 2 m spacing. A Wenner-Schlumberger measuring sequence (with a total of 1247 measuring quadrupoles) was used in order to obtain a good compromise between both vertical and lateral resolution. Acquired data were processed by the commercial inversion code Res2Dinv® (Loke & Barker, 1996). After preliminary data filtering a good convergence of the results has been obtained with RMS error below 2 %.

3. RESULTS

The most common sediments outcropping in the Valmaggiore sector, texturally heterogeneous and very compact, are referred to the San Martino Unit

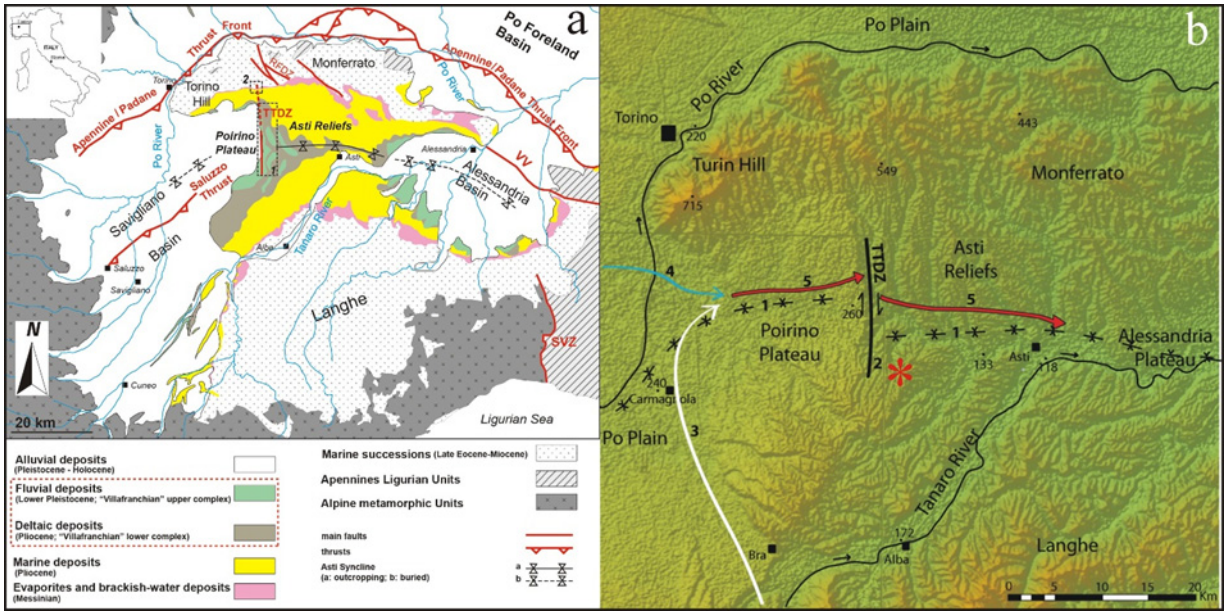

Fig. 1 - a) Simplified geological map of the Piedmont hilly region with the location of the TTDZ; b) Aster Global DEM (NASA-MITI, Dec. 2009) showing the scarp between the Poirino Plateau and the Asti Reliefs. (1) Asti Syncline axis; (2) T. Traversola Deformation Zone (TTDZ); Upper Pleistocene ancient course of rivers: (3) Tanaro, (4) Po, (5) Po and Tanaro. The asterisk indicates the location of Fig. 2 (from Gattiglio et al., 2015).

("villafranchian" Lower Complex) (Fig. 2). They consist of predominantly planar bedded to massive clayey silt, that is typically grey, rich in scattered leaf and reed imprints, plant fragments, roots and pollen. The fine facies and fossils are usual in swamp environments where the mineral fraction and vegetal remains decanted in the water column. Trough cross-bedded sand forms the fills of channel. The sandy texture, cross bedding and local vertebrate remains suggest a stream environment. The association of these two facies is typical of plain deltaic environment. Specifically, the silt was deposited in coastal swamps, and the sand filled the deltaic distributary channels. The contact with the Upper Complex is marked by the Cascina Viarengo unconformity that represents the result of erosional phenomena that caused a progressive thickness reduction of the San Martino Unit towards the south.

Trough cross-bedded sediments with a component of minute gravel, referred to the Cascina Gherba Unit ("villafranchian" Upper Complex), cover the previous unit. The gravelly-sandy texture and the absence of fossils suggest that they are associated to a fluvial channel environment. Clayey silt forms the top of the "villafranchian" succession, referred to the Maretto Unit ("villafranchian" Upper Complex). It appears very weathered in its whole thickness (in consequence of several superimposed soils) and rich of carbonatic concretions. The silty-clayey texture and the strong weathering indicate that these sediments are associated to a continental fluvial plain in which the soils developed already during the sedimentation (Forno et al., 2015).

The sedimentary succession in the Valmaggiore sector is dissected by many fractures striking from N350° to N10°, dipping towards the east and representing a fault system approximately characterised by N-S trend (Fig. 3a). This system, only locally associated to soft sediment deformation, dislocates the whole sedimentary succession, involving both sediments of "villafranchian" Lower and Upper complexes. The geological evolution of this system occurred, therefore, in a long time spam, from a syn-sedimentary activity during the Piacenzian to a post-sedimentary movement during the Upper Pleistocene. Geological survey suggests that the western sector appears uplifted compared to the eastern one, evidencing an inverse component of movement.

Furthermore, the thickness of the San Martino Unit is greater in the eastern sector respect to the western one. The overall thickness change of these sediments (with values progressively increasing towards the north) suggests also a remarkable dextral strike-slip component for this fault.

The geomorphological evidence also contributes to the tectonic reconstruction. The current watercourses essentially have N-S trend, different from their Upper Pleistocene configuration characterised, instead, by W-E main watercourses along the Asti Syncline axis. The current drainage network seems to be therefore driven by the N-S tectonic system, showing main stream flow (N-S) that superimposes a previous flow direction (W-E) (Fig. 1b).

A minor fault system showing N150° trend with an extensional component (lowering toward west) is also observed. It dislocates only part of "villafranchian" Low Complex, also creating small scarps SE of Case Sossi. Chaotic sediments, locally occurring in the lowered sector (asterisk in Fig. 2), contain decimetric silty and sandy fragments characterised by various arrangement (Fig.

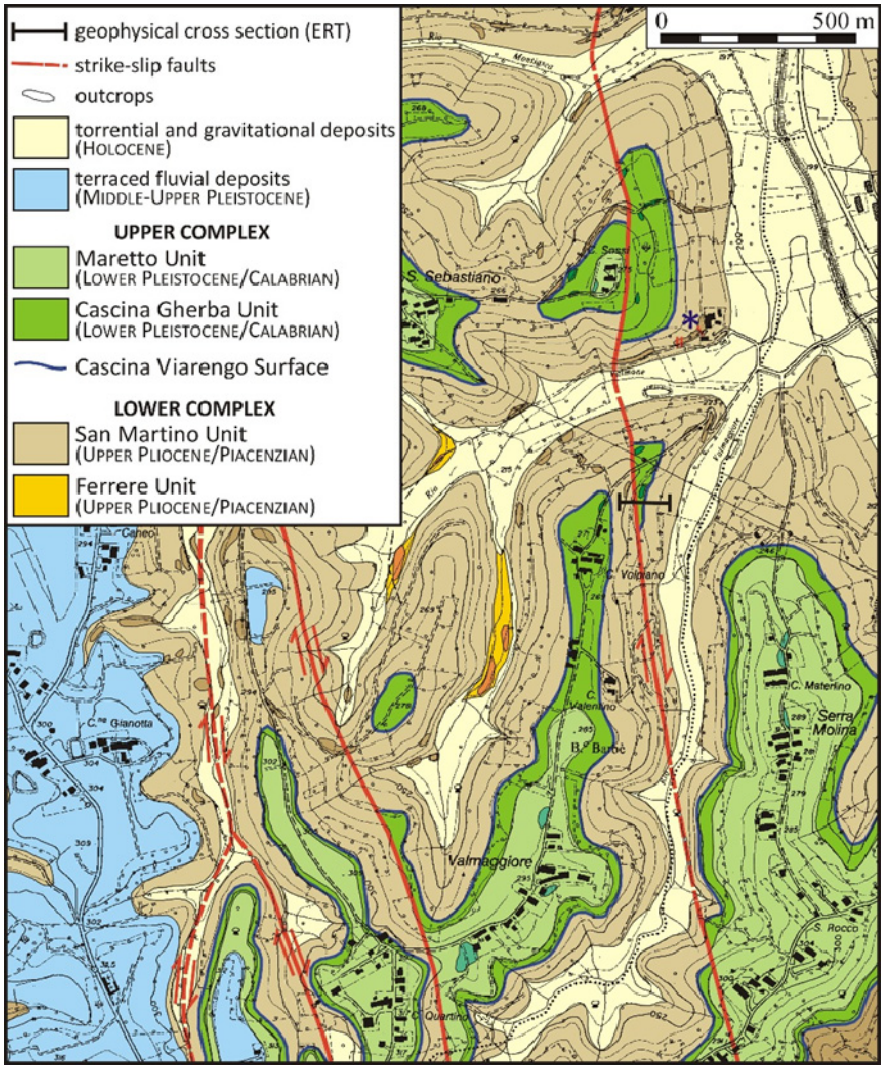

Fig. 2 - Detailed geological map of the Valmaggiore area, showing a N-S fault system referred to the TTDZ. The asterisk indicates the reworked sediments of the San Martino Unit.

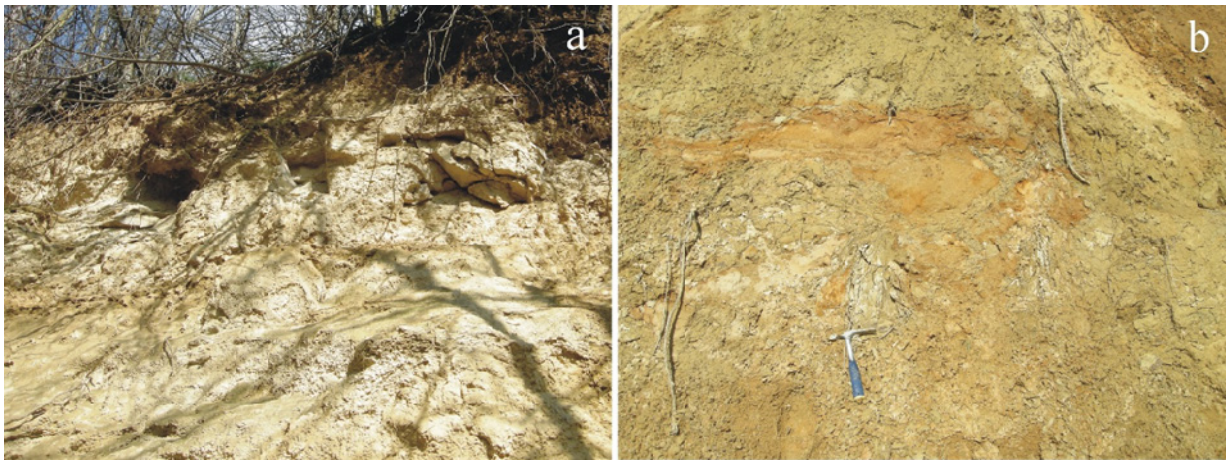

Fig. 3 - a) N-S faults referred to the TTDZ; b) Chaotic sediments connected to reworking of the deltaic plain body (500 m south of Case Sossi).

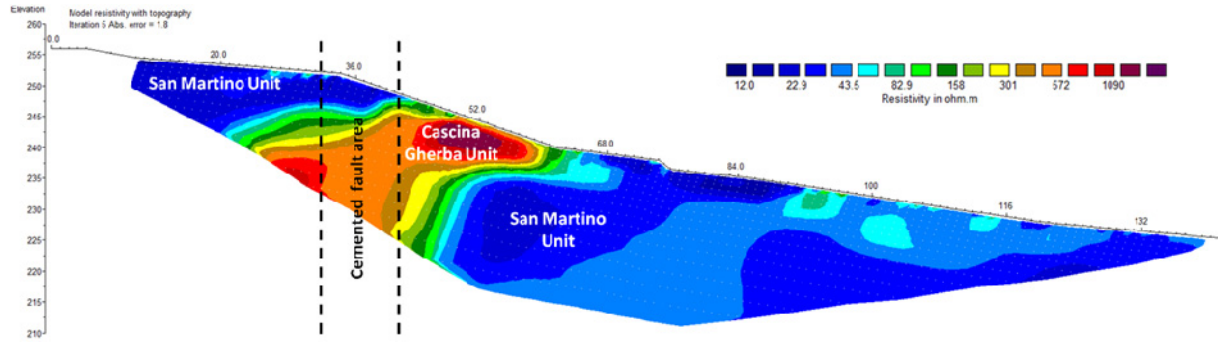

Fig. 4 - Resistivity distribution along the Cascina Volpiano geophysical survey line, with reported geological interpretation.

3b). Here trough cross-bedded sand connected to a filled channel also locally crops out, above the reworked body. The chaotic body is due to gravitational reworking phenomena of sediments as well as the location of the channel corresponds to the lowered sector. The N150° fault system is sealed by deltaic plain sediments (San Martino Unit), suggesting a syn-sedimentary tectonics.

This geological reconstruction is also supported by the resulting resistivity distribution along the geophysical survey line (Fig. 4). A marked sub-horizontal resistivity anomaly is observed along the E-W geophysical cross section in a surficial localized body approximately at progressive 52 m. This zone shows higher resistivity values (around 1000 Ohm.m) with respect to the surrounding. This body is laterally interrupted by a sub-vertical band showing a minor resistivity anomaly approximately at progressive 36 m.

The comparison between geological data (showing an isolated body formed by gravelly sand interrupted by a N-S fault system) and geophysical results suggests that these anomalies can be associated to cemented gravelly sand belonging to the Cascina Gherba Unit, interrupted by a cemented sub-vertical band referred to the N-S fault system (Fig. 4). The lower resistivity values observed (around 15 Ohm.m) around this zone can be attributed to the silt of the San Martino Unit, with subordinate fine sand. The geophysical evidence supports therefore the geological reconstruction of a fault dislocating the stratigraphic continuity of sedimentary bodies.

4. DISCUSSION AND CONCLUSION

The detailed geological survey allowed to observe that the stratigraphic succession is characterised by sub-vertical geological contacts as well sediments connected to gravitational reworking of the deltaic body. On the base of the geological and geomorphological evidences a fault of the TTDZ has been detected around Cascina Volpiano. The comparison between geological and geophysical data also allows to confirm the presence and location of this fault. The Electric Resistivity Tomography indicates the prosecution of the fault system in the shallow subsoil and the anomalous cementation of sediments along this system, already observed in other sectors. A strike-slip component of the N-S fault is evidenced by the thickness change of San Martino Unit, according to the main strike-slip evolution of the TTDZ. This deformation zone also comprises N150° faults testifying syn-sedimentary tectonics. The tectonic evolution along the TTDZ, dislocating both complexes of the "Villafranchian" succession (referred to Piacenzian and Calabrian), took place in a long time interval and possibly is still active as suggested by the present microseismicity.

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Ms. received: May 9, 2018
Final text received: May 23, 2018