Introduction. The study area belongs to the Plio-Quaternary front of the eastern Southalpine Chain (ESC), a SSE verging, WSW-ENE striking fold and thrust belt in evolution from the Middle Miocene to the Present (Fig. 1).

Up to now the ESC thrust-system accommodates the present 2 mm/y shortening (Serpelloni et al., 2005) and crustal thickening and propagates towards the Friulian piedmont Plain.

The Venetian-Friulian prealpine area is characterized by medium/high seismicity both instrumental and historical. According the DBMI11 (Locati et al., 2011) many M>6 historical earthquakes hit the Prealpine area: 1117 (Verona), 1348 (Carnia), 1695 (Asolo), 1873 (Belluno), 1936 (Bosco del Cansiglio) and 1976 (Friuli). The DISS3 Catalogue (http://diss.rm.ingv.it/dissNet/) shows three seismogenetic sources in the investigated area: the Maniago source that is considered responsible for the 07/10/1776 Tramonti earthquake; the Tramonti source linked to the 07/06/1794 earthquake and the Sequals source that is considered a silent source because of no historical earthquakes can be referred to this fault until now (Burrato et al., 2008).

In order to define the upper Pleistocene – Holocene tectonic activity of Southalpine chain in the Carnic Prealps we carried out a morphotectonic analysis of the terraced succession and the related sedimentary units in the lower reach of the Meduna valley.

Stratigraphic and structural framework. The structural framework of the investigated area is characterized by the M. Jouf-Maniago thrust-system (JM in Fig. 1) dealing with two arched WSW-ENE striking, SSE-verging thrusts (the Maniago and Mt. Jouf respectively), bordering the prealpine area between Maniago and Forgaria del Friuli, south the Periadriatic thrust (PE in Fig. 1).

The JM strongly involves the pre-Quaternary succession that in the study area starts with the Upper Jurassic–Upper Cretaceous Friulian Carbonate Platform that drowned during the Paleogene because of the westward propagation of the front of the External Dinarides. The platform was buried by the Scaglia Rossa Friulana hemipelagic unit and by the thick turbiditic sequence of the Clauzetto Flysch during the Lower Eocene. Starting from the Aquitanian, the Cretaceous and Paleogene formations were unconformably covered by the thick (about 3000 m) Miocene clastic wedge of the eastern Southalpine Chain foredeep (Massari et al., 1986; Zanferrari et al., 2008 and references therein).
The Quaternary successions within the Meduna valley are discontinuous and lacking in chronological data. Better preserved successions are located in the lower reach of the valley, at Ponte Racli with the occurrence of lacustrine bodies interbedded with deltaic or fluvial deposits, ascribed to downstream damming by moraines (Venturini, 1985) and at Del Bianco village, where fluvial conglomerates, glacial and glaciolacustrine sediments were described by Feruglio (1929). However, no specific studies are so far available for the terraces at the outlet of the valley. On the contrary, the geological surveys for the CARG-FVG Project (Zanferrari et al., 2008) let the reconstruction of the late Quaternary evolution of the Meduna alluvial fan (Avigliano et al., 2002).

From a structural point of view, the JM gives rise to a km WSW-ENE striking, S-vergent M. Ciaurlec anticline that involves both the Upper Jurassic-Upper Cretaceous Friulian Carbonate Platform and its Tertiary siliciclastic roofing. Moreover the prevailing siliciclastic Tertiary succession (Scaglia Rossa, Clauzetto Flysch and Miocene succession) gives rise to a WSW-ENE anticlines-synclines tight fold-system. East of Meduno locality, this structural framework shows a noticeable undulation, probably reflecting a Cretaceous or Eocene paleostructure and causing a NW-SE striking transpressive transfer zone.

Evidence of JM Quaternary activity is shown near Maniago locality, where the terraced Middle-upper Pleistocene units (respectively Maniago gravels and Maniago conglomerates: Zanferrari et al., 2008) are uplifted and suspended on the present piedmont plain by the activity of the M. Jouf thrust; moreover, along the Colvera creek lacustrine deposits (9090 ± 90 years 14C BP) are gently folded and fractured (Zanferrari et al., 2008).

South of the JM, the Miocene succession is thrust and folded by the Arba-Ragogna thrust-system (AR in Fig. 1). It shows evidence of Quaternary activity, as testifies the angular unconformity between the Lower Messinian (Montello conglomerate) and the Early Quaternary

Fig. 1 – Structural sketch of NE Italy and W-Slovenia. In the red rectangle the study area. JM: M. Jouf-Maniago thrust-system; AR: Arba Ragogna; PE: Periadriatic thrust (mod. after Zanferrari et al., 2013).
(San Pietro di Ragogna conglomerate) (Zanferrari et al., 2008; Poli et al., 2009). The recent tectonic activity of the Arba-Ragogna thrust system is also testified by drainage anomalies and gentle scarps connecting uplifted paleolandslides of Quaternary age (Galadini et al., 2005; Monegato et al., 2010). A vertical slip-rate of about 0.19 mm/y has been calculated during the last 21 kys (Poli et al., 2009).

The sedimentary units and terraced staircase at the outlet of the Meduna valley. Detailed stratigraphical and morphotectonic studies of the terraced surfaces at the outlet of the Meduna valley (south of Ponte Racli locality) allow to detect 9 depositional units (Q1 - Q9 in Fig. 2) linked to alluvial (Q1, Q2, Q3, Q5, Q6, Q7, Q8, Q9) or glacial (Q4) paleo-environments. Starting from the available chronological data for the Meduna alluvial fan (Avigliano et al., 2002; Zanferrari et al., 2008), the geometric relationships between the observed units and the terraced surfaces pinpointed to a succession of depositional events from the Early Pleistocene to the Holocene (Fig. 2). Q4, Q5, Q7, Q8 e Q9 units are terraced but the thickness of the deposits is not steady, for which a distinction between “strath terrace” and “fill terrace” (sensu Bull, 1991) can be adopted. A “strath terrace” is characterized by thin deposits (<3m) above an erosion surface on the bedrock; whereas the “fill terrace” is characterized by thicker preserved deposits. According Wegmann and Pazzaglia (2009) this subdivision is a key parameter for discussing the genesis of the terrace staircase in tectonically active areas.

Deformational events. The reconstruction of the deformative events is based both on morphological (piracy and valley deepening) and tectonic evidence. Starting from the older we identified four deformative events (Fig. 2).

1. Early Pleistocene (Gelasian). This event can be morphologically recognized by the main changes in the valley drainage that took place in the Meduna catchment: from the path across the present Forchia di

<table>
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<tr>
<th>Chrono-stratigraphy</th>
<th>Time (Ma)</th>
<th>Oxygen Isotope curve (Lisiecki and Raymo, 2005)</th>
<th>Meduna valley stratigraphy</th>
<th>Deformation phase</th>
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</tr>
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<td><img src="image" alt="Oxygen Isotope Curve" /></td>
<td>Meduna through the Forchia di Meduna windgap</td>
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Fig. 2 – Chrono-stratigraphical sketch of sedimentary units (Q1-Q9) and tectonic events (1-4) recognized at the outlet of Meduna Valley. Unit Q4 is not dated and can be ascribed to only one of the glacial maxima linked with arrows.
Meduno windgap (Fig. 2), the river shifted towards the west deepening the valley of about 200 m. This change was tentatively correlated to the deformation phase well recognized in the foothills (Caputo et al., 2010). The new Meduna valley crossed the Periadriatic thrust (PE in Fig. 1) whose activity may have driven the geomorphological change. In addition, the thick Q1 conglomerate, exceeding 40 m, suggests a local subsidence at the footwall of the Periadriatic thrust itself.

2. **Calabrian (?)**. A second important deepening of the valley, of about 150 m, with a westward shifting, occurred between Q1 and Q2 aggradation phases. However, the lack of chronological data for these two units makes speculative the age attribution of this phase. It is likely that a tectonic uplift drove this deepening, but it needs more investigations.

3. **Calabrian-Middle Pleistocene**. This event is recognizable at the boundary between Q2 and Q3 units. Here the Q2 conglomeratic unit presents a crude bedding, gentle folding (dip ca. 10-15°, from 340° to 45°). The Q2 unit is unconformable cut by another conglomerate (Q3) horizontally bedded. Both can be ascribed to alluvial sedimentation of the Meduna Stream within a valley reach, while the angular unconformity suggests a relative time-span occurred between their deposition. Moreover, Q4 is related to a glacial advance during the late Calabrian – middle Pleistocene (Fig. 2), suggesting a similar age for the deformation. An angular unconformity ascribed to the same time span is visible in the conglomerate succession of the Tagliamento valley (Monegato and Stefani, 2011).

4. **Middle-upper Pleistocene-Holocene**. This tectonic event involves both the M. Jouf thrust and the Maniago one, showing a clear shifting of the tectonic activity from the inner thrust (M. Jouf th.) to the external one (Maniago th.). It is the better constrained tectonic event.

On the terrace near Meduno, the Q5 unit (Middle Pleistocene, upper portion, Fig. 2) give rise a transition from “strath terrace” located in the hangingwall of the M. Jouf thrust to “fill terrace” in the footwall of the thrust. Therefore according to Wegman and Pazzaglia (2009) a broad tectonic control on the formation of this terrace can be hypothesized.

Moreover, Q1 unit (Del Bianco conglomerate, probably Early Pleistocene in age) is crosscut by the M. Jouf thrust. Here the conglomerate is strongly fractured and tilted back of about 20°.

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**Fig. 3 – NW-SE geological profile across the LGM terrace on left side of Meduna Stream near Ponte Maraldi. Q6: Ponte di Pietra sedimentary unit (upper Pleistocene); Q7: Sequals syntem (Travesio lobe, upper Pleistocene – 22-23 ka cal. BP); Q8: Sequals syntem (Arba lobe upper Pleistocene-Holocene). TRZ: Tarzo Marl (Lower Serravallian-Lower Tortonian); VVE: (Vittorio Veneto Sandstone, Tortonian); MON1 and MON2: Montello Conglomerate members (Upper Tortonian-Lower Messinian).**

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196
On the left side of the Meduna river near Ponte Maraldi, the Q7 unit (Sequals syntem, Travesio lobe, upper Pleistocene according to Zanferrari et al., 2008) presents a throw of about 25 m on the Maniago thrust (Fig. 3). On these bases an uplift rate of about 1.1 mm/y can be evaluated. Moreover the terrace surface on the Q7 unit near Maraldi presents a fault scarp of about 7-8 m. Instead on the hangwall of the Maniago fault the thickness of the Q7 unit is very thin (close to the “strath terrace” definition), on the contrary in the footwall of the thrust the alluvial deposits are more than 20 meters in thickness (“fill terrace”).

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