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PRELIMINARY CONTRIBUTION OF THE GEOMORPHOLOGICAL ANALYSIS IN THE EVALUATION OF RECENT TECTONIC CONTROL IN THE TAMMARO RIVER CATCHMENT (CAMPANIA – MOLISE)

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ABSTRACT: Cartojan E., Magliulo P. & Valente A., *Preliminary contribution of the geomorphological analysis in the evaluation of recent tectonic control in the Tammaro River catchment (Campania – Molise).* (IT ISSN 0394-3356, 2011)
The aim of this study is to highlight the preliminary results derived to the integrated geomorphological analysis of the Tammaro River catchment (Campania – Molise) in order to recognize the role played by the recent tectonic activity in development and the evolution of the hydrographic network.

RIASSUNTO: Cartojan E., Magliulo P. & Valente A., *Contributo preliminare dell'analisi geomorfologica nella valutazione dedel controllo della tettonica recente sul bacino del Fiume Tammaro (Campania – Molise).* (IT ISSN 0394-3356, 2011)
L'obiettivo del presente lavoro è quello di illustrare i primi risultati ottenuti dall'analisi geomorfologica integrata del bacino del Fiume Tammaro (Campania - Molise), finalizzata al riconoscimento di un eventuale influenza da parte della tettonica recente sullo sviluppo e sull'evoluzione del reticolo idrografico.

Key words: Quantitative geomorphology, Geographic Information System, Hypsographic Integral, Recent tectonic, Campania – Molise.

Parole chiave: Geomorfologia quantitativa, Sistema Informativo Geografico, Integrale Ipsografico, Tettonica recente, Campania – Molise.

1. INTRODUCTION

The aim of this study is to highlight the role played by the recent tectonic activity in the Tammaro River basin (Campania - Molise) as revealed by the organization and the evolution of the hydrographic network. The geomorphic processes currently occurring in the basin, represented by landslides and linear erosion, have also been taken into account. Different types of investigation, such as quantitative geomorphic analysis, hypsometric analysis and statistical azimuthal distribution of river courses, integrated into a GIS environment, have been used. They have provided some preliminary results concerning the widest and hierarchically highest sub-basins of Tammaro River catchment.

Study area. The Tammaro River, ~78 km-long, starts from a series of relieves belonging to the Matese massif, located in the Molise region. It is a 7^{th} order tributary of the Calore River and receives 22 major tributaries. The basin is NW-SE elongated and is ~ 670 km^2-wide; it shows a slightly concave side towards SW. The morphology of the basin is markedly asymmetrical, as the southwestern side displays the highest slope angles. Thus, both the altitude and the slope angle ranges are irregularly distributed on the two sides of the basin. As a consequence, also the evolution and the hierarchy of the hydrographic network are different (Fig. 1). From a geological point of view, the outer units of the southern Apennine chain are present in the studied basin. They are mostly made up by deposits accumulated in the basins deformed by tectonic phases occurred between Tortonian and Pliocene (CASNEDI *et al.* 1982). These deposits mainly consist of sandstone and/or clay alternated with marl and limestone, belonging to the Sannio and Fortore tectonic units (PESCATORE *et al.* 2008 *cum bibl.*). The Quaternary deposits are represented by scree-talus and alluvial deposits: the oldest are fine-grained and of fluvio-lacustrine origin, while the most recent are medium- or coarse-grained (BERGOMI *et al.* 1975). The area is also affected by a complex pre-Quaternary fault system, with a NW-SE and NE-SW orientation, which strongly affects the physiography and hydrography (PESCATORE *et al*. 2008). Some recent tectonic features, E to W and N to S elongated, also occurs (PESCATORE *et al.* 1996). These features are rarely evident in the field, because of the prevalence of poorly conservative lithotypes (APAT, 2007), often involved into landslides.

2. TOOLS AND METHODS

Data were collected using a GIS (Geographical Information System) software by digitizing the drainage network on the basis of geo-referenced maps. These maps belong to the topographic map of Italy at 1:50,000-scale (nn. 405, 406, 418, 419, 432). In such way, it was possible to create a database containing all the information and the results concerning the selected sub-basins, which were

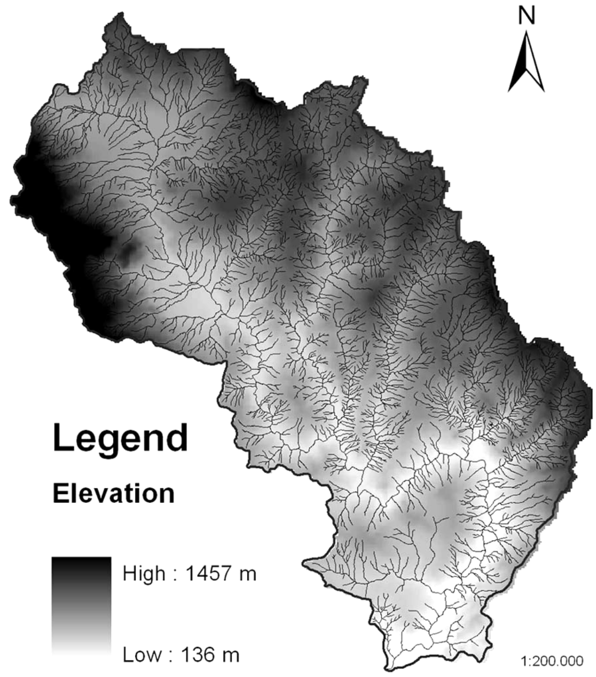

Fig. 1, DEM (*Digital Elevation Model)* of the Tammaro River catchment.
Modello Digitale di Elevazione del bacino idrografico del F. Tammaro.

investigated using different methods. In particular, the morphometric features of the each sub-basin have been defined by means of geomorphic quantitative analysis (CICCACCI *et al*. 1980; 1988; LUPIA PALMIERI *et al*. 2001). At first, the hydrographic network has been ordered according to the method of STRAHLER (1954); then, the bifurcation ratio (Rb), the direct bifurcation ratio (Rbd) and the bifurcation index (HORTON, 1945; AVENA *et al.,* 1967) were calculated. Furthermore, in order to define more objectively the degree of hierarchy, the following parameters have been calculated: the hierarchical anomaly number (Ga), the hierarchical anomaly density (ga) and hierarchical anomaly index (Da) (AVENA *et al*., 1967). Finally, using the percentage method of STRAHLER (1952) the hypsographic curves of each basin were built and their relative hypsometric index values (HI *Hypsometric Integral*) were calculated by using the method of *Elevation-Relief Ratio Relationship* (KELLER & PINTER., 2002). The hypsometric analysis provides useful information for the morphodynamic characterization of a given landscape (LUPIA PALMIERI *et al.,* 2001), while the value of the hypsometric integral allows the parameterization of the basin in relation to the Davis' cycle of erosion.

3. DATA ANALYSIS

Figure 2 and Figure 3 show high values of the bifurcation ratio for the streams of Sanzano (Rb = 5.43) and Reinello (Rb = 7,44). In general terms, values higher than 5 indicate that, almost certainly, basins are strongly controlled by tectonics (CICCACCI *et al.,* 1980). Such a conclusion is also corroborated by the bifurcation index values (R), that are higher than 2 in both cases (2.55 and 2.10, respectively), indicating a low hierarchy in the geometry of the basins. For all the investigated sub -basins, low values of the hierarchical anomaly density (ga) and hierarchical anomaly index were generally found. They are usually typical of well-organized catchments and this is in strong contrast to the R and Rb values listed above. This discrepancy can be explained taking into account the lack of objectivity of the bifurcation ratios, which do not consider the influence of hierarchical anomalies. By combining this analysis with the study of hypsographic curves (Fig. 4) and related indices, a predominance of convex curves, with HI> 0.55, was noted. Such HI value is attributed by CICCACCI *et al*. (1988) to basins in a "phase of disequilibrium" or in a "juvenile" stage (*sensu* STRAHLER, 1952), and therefore it is associated with a prevailing vertical erosion by the watercourses. However, the presence of inflection within the hypsographic curves suggests that the morphogenetic processes are very complex, differing along the watercourse,

	A kmq	P km	N	ordine	Rb med	Rbd med	R med
Sanzano	20,15	23,41	157	4	5,43	3,73	2,55
S. Giorgio	19,23	20,13	182	4	5,34	4,58	1,14
S. Marco	38,03	32,49	255	5	3,92	2,96	1,28
Reinello	57,15	43,36	394	4	7,44	6,04	2,10
Rio Freddo	22,80	25,80	169	4	5,20	4,17	1,54
RioGrande	27,00	25,06	268	5	3,83	2,87	1,27

Fig. 2, Morphometric parameters: A) Surface; P) Perimeter; N) Number of streams; Rb) Bifurcation ratio; Rbd) Direct bifurcation ratio; R) Bifurcation index.
Parametri morfometrici: A) Area; P) Perimetro; N) Numero di aste fluviali; Rb) Rapporto di biforcazione; Rbd) Rapporto di biforcazione diretto; R) Indice di biforcazione

	Ga	ga	Δa	D	Tu t/kmq year	log Tu t/kmq year	HI
Sanzano	110	5,46	0,84	3,66	485,85	2,69	0,62
S. Giorgio	99	5,15	0,70	3,80	512,04	2,71	0,59
S. Marco	333	8,76	1,67	3,64	644,87	2,81	0,56
Reinello	263	4,60	0,86	3,69	499,72	2,70	0,47
Rio Freddo	96	4,21	0,69	3,77	501,08	2,70	0,61
RioGrande	284	10,52	1,41	3,95	747,50	2,87	0,39

Fig. 3, Morphometric parameters: Ga) Hierarchical anomaly number; ga) Hierarchical anomaly density; Δa) Hierarchical anomaly index; D) Drainage density; Tu) Suspended sediment yield (t/square km/year); HI) Hypsometric Integral
Parametri morfometrici: Ga) Numero di anomalia gerarchica; ga) Densità di anomalia gerarchica; Δa) Indice di anomalia gerarchica; D) Densità di drenaggio; Tu) Trasporto torbido unitario medio annuo; HI)Integrale Ipsometrico

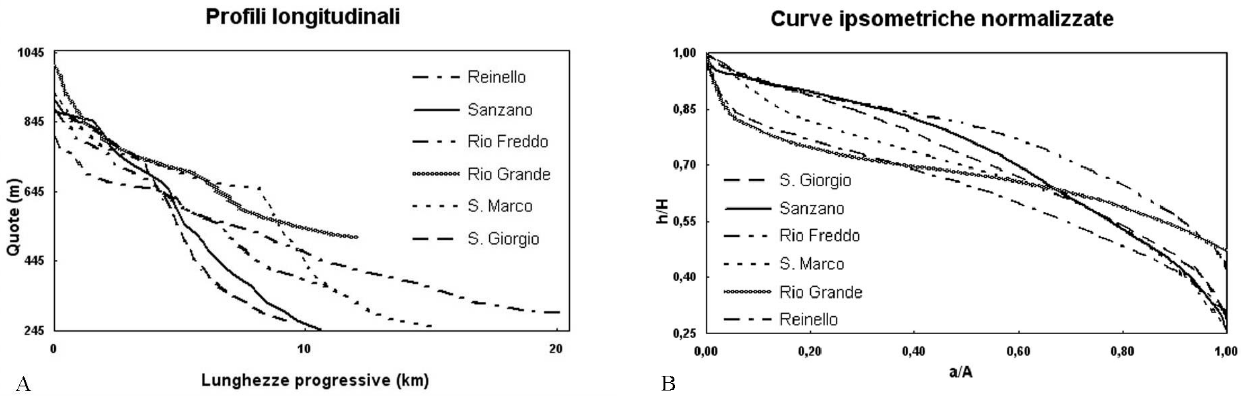

Fig. 4, A) Longitudinal profiles of the analysed sub-basin; B) Normalized hypsografic curves.
A) Profili longitudinali dei sub-bacini analizzati; B) Curve ipsometriche normalizzate.

with a predominant areal erosion on slopes in the upper parts of the basins and an increase of linear erosion in the lower parts.

In conclusion, the preliminary results obtained from the present analysis are in agreement with previous studies dealing with recent tectonics (NAPPI *et al.,* 2007). Such studies pointed out the presence of a NW-SE trending active structural side, that is highlighted by the longitudinal profiles showed in Fig. 4A, that display a clear knickpoint at the altitude of 600÷700 m.

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