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GRAVINE: PECULIAR MORPHOLOGICAL ELEMENTS OF THE LANDSCAPE IN SOUTH-EAST ITALY

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EXTENDED ABSTRACT

Le "Gravine" sono uno degli elementi peculiari del paesaggio dell'Italia sud-orientale, in particolare dell'area della provincia di Taranto fino a Matera. Esse caratterizzano il bordo sud-occidentale dell'altipiano delle Murge: un vasto affioramento calcareo del Cretaceo, del dominio dell'Avampaese Apulo. Sono delle valli strette e profonde, sino ad oltre 200 m, orientate essenzialmente secondo la direttrice appenninica nord-ovest sud-est, anche se il loro andamento locale è molto irregolare e tortuoso. Sono incise in parte nei litotipi delle Calcareniti di Gravina (Pliocene Sup. Pleistocene Inf.) ed in parte, nella porzione inferiore, nei Calcari di Altamura (Createaceo). Localmente questi ultimi affiorano dal fondo sino alle quote più alte dei fianchi delle gravine, laddove lo strato calcarenitico risulta particolarmente poco potente o assente.

Nel presente lavoro sono illustrati alcuni caratteri peculiari delle gravine insieme ad una serie di riflessioni critiche circa la loro genesi ed evoluzione in relazione alle particolari caratteristiche geologiche e geomorfologiche che le contraddistinguono. Sono caratterizzate da fianchi molto ripidi e da uno sviluppo planimetrico fortemente irregolare, pur se nel complesso presentano una orientazione abbastanza netta. Le gravine sono percorse da corsi d'acqua a carattere effimero che presentano, spesso, una porzione di bacino a monte ed a valle che si sviluppa in zone caratterizzate da affioramenti di litotipi Quaternari con morfologie ordinarie. Nei tratti in "gravina" la pendenza del thalweg risulta di norma significativamente maggiore a rispetto a quella dei tratti a monte ed a valle ed il un reticolo idrografico risulta poco o per niente gerarchizzato.

L'insieme delle caratteristiche e peculiarità di questi elementi morfologici, nel complesso fa ritenere che tali incisioni vallive possano essere ricondotte a meccanismi di fratture profonde che interessano il margine occidentale dell'Avampaese Apulo in un contesto tettonico transtensivo, piuttosto che essere il risultato della semplice morfogenesi fluviale e/o carsica. Il che risulta in linea anche con i modesti volumi detritici delle conoidi alluvionali in relazione all'ampiezza dei volumi che sarebbero stati erosi. Peraltro questi corsi d'acqua effimeri presentano a monte bacini imbriferi di dimensioni relativamente modeste in cui l'attivazione di un deflusso avviene solo in conseguenza di eventi meteorici eccezionali, allorquando il ruscellamento superficiale trova nelle gravine delle vie di deflusso preferenziali.

Pertanto la loro origine può essere ipotizzata in relazione a fenomeni di geologia strutturale, invece che in conseguenza dell'erosione causata dal deflusso indotto dal ruscellamento superficiale o dello sviluppo di fenomeni carsici.

ABSTRACT

The landscape of the area on the boundary between Basilicata and Apulia, in south-east Italy is characterized by the presence of deep narrow valleys, i.e. ravine, named *gravine*. These develop at the western bound of the calcareous horst named Murge highland that is part of the Cretaceous calcareous bedrock of the Apulian Foreland domain, oriented along NW-SE direction. These ravines show typical peculiarities, which make their origin quite controversial. Traditionally, they are believed as erosive or karst valleys, cut by the action of the runoff water. However, they show an irregular state of hydrographic evolution, arising several doubts about their genesis. Here, the specific characteristics of the ravines of Matera and Ginosa are briefly analyzed and presented for emphasizing their common particular features, introducing some notes and alternative interpretations about their genesis and evolution.

Keywords: *ravine; geomorphometric Analysis, Gravina di Matera; tectonic stress; morphogenesis*

INTRODUCTION

The west southern boundary of the Apulian carbonatic platform, at the transition between the Apulian foreland and the Bradanic foredeep domains (Doglioni *et alii*, 1994, Vv. Aa. 2010) in south east Italy, is characterized by the presence of deep narrow valleys, which can be identified as ravines, locally named "*gravine*". These morphological elements show similar morphological features, but having variable lengths and depths. The upper part of their flank is graven in the Plio-Pleistocenic calcareous sandstone named Gravina Calcarenites (Cotecchia & Grassi, 1975; Simeone *et alii*, 2019). The bottom is in the Cretaceous limestones formation of Altamura Limestone (VV. AA., 2010; Ciaranfi *et alii*, 1988). Ravines locally have severely irregular paths, sometimes with some sort of local meanders often oriented along the WSW-ENE. Anyway, their overall orientation is along NNW-SSE direction, parallelly to the Apennine direction.

Their catchment areas mainly develop in the Apulian foreland domain, on Murgia, see Fig. 1, being characterized by a diffuse outcropping of intensively fractured and karstified Cretaceous limestones. The depth of *gravine* ranges between few tens of meters up to over 200 m. Downstream the ravines, the landscape is characterized by large flat areas, which develop until the coast and where recent alluvial deposits diffusively outcrop, even if their thickness is quite small with respect to the depth of ravines. Ravines normally are part of the shallow hydrographic network, which is made of ephemeral streams, normally dry, where calcarenites and limestones outcrops. They occasionally drain the runoff generated by extreme rainfall events (Doglioni *et alii*, 2015). However, most of the year they are completely dry or there is a minimal discharge. Their profiles are characterized by steps and severe acclivity.

The genesis of these deep valleys is controversial (Cristino *et alii*, 2015), since they were traditionally considered as consequence of streamcutting erosion or evolution of karst phenomena. However, due to their slope and to their paths, besides considering their depths, it may be more likely that these valleys were originated by the deep cracking of the Apulian platform during its uplift, due to tectonics of Pleistocene Apennine orogenesis (Doglioni *et alii*, 1994). These cracks likely started working as drain paths for runoff, being the relatively easiest flow-path (Doglioni *et alii*, 2012). Here, this idea is explored, starting from some analysis on the shapes and on the evolution of the ravines, particularly looking at some of the largest and deepest ravines: Matera and Ginosa, see Fig. 1.

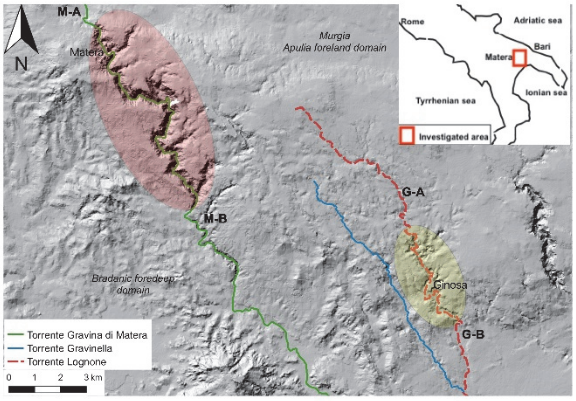

Fig. 1 - Location of the ravines and investigated region, the stretches of ravines are highlighted with a red ellipse for Matera and with a yellow ellipse for Ginosa

THE INVESTIGATED SITES

The ravine of Matera

The ravine stretch is part of the stream named Torrente Gravina di Matera, which is 59.6 km long, being tributary to river Bradano, see Fig. 1. Its catchment area is 430 km^2, originating from the north-east bound of the Bradanic foredeep domain with Murgia plateau. The geology of the catchment area can be divided in two parts: in the eastern subcatchments Cretaceous limestones diffusively outcrop, while in the western catchments the foredeep deposits outcrop, in particular Plio-Pleistocenic calcarenites, Sub-Apennine clays (Plestocene) and sands and recent alluviums (upper Pliocene and Holocene). The ravine cuts Cretaceous limestones and Plio-Pleistocenic calcarenites, whereas the latter outcrop on the sides of the ravine with thickness up to few tens of meters. The central stretch of the ravine shows an apparent meandering path, which seems to be due to the irregular aspect of a tensile fracture. On the other hand, fluvial meanders are not congruent with the slope of their thalweg. Fig. 2a shows the longitudinal profile of Torrente Gravina di Matera; a representative transects of the ravine is shown by Fig. 2b. Fig. 3a shows the hypsometric curve of Torrente Gravina di Matera, while Fig. 4a shows its Rose diagram, referred to the stretch ranging between M-A and M-B, see fig. 1, of Torrente Gravina di Matera. It is noteworthy that the geomorphic evolution stage, emphasized by the hypsometric curve of the stretch M-A to M-B, denotes an early stage evolutive phase (FERRO, 2006), which is apparently not consistent with the severe streamcutting of the Cretaceous limestones. Similarly, it is very interesting to observe that Rose diagram shows a predominant direction of the ravine, which is

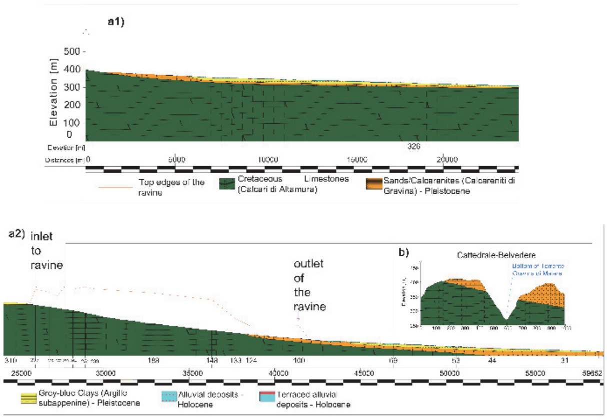

Fig. 2 - a) Longitudinal profile of the ravine; b) transect of the ravine of Matera

The ravine of Ginosa

Gravina di Ginosa is part of an ephemeral stream, named Torrente Lognone, which is 29.4 km long, being tributary of River Bradano, see Fig. 1. The total catchment area of Torrente Lognone is 82.06 km^2, including the subcatchment of a right-side tributary, named Torrente Gravinella. The catchment originates from Murgia platform, where Cretaceous limestones diffusively outcrop, then, arriving on the southern edge of Murgia, it passes through Plio-Pleistocenic calcarenites, where the morphology becomes a ravine. Downstream the ravine, the river passes through upper Pleistocenic deposits, up to the confluence with River Bradano. The ravine appears tectonically controlled: the meanders of the ravine with the particularly tortuous path around the northern and east limit of the town, may be associated with the presence of a transcurrent and distensive faults (GUERRICCHIO & MELIDORO, 1986; BENTIVENGA *et alii* 2004). These are likely related to the tectonics of the Apennine, which generated a sequence of distensive and transcurrent discontinuities, particularly visible in the alluvial deposits of the plain downstream Murgia towards the Ionian Sea. In order to estimate the morphoevolutive stage of the ravine, the hypsometric curve of Torrente Lognone is constructed between the points G-A and G-B, shown by Fig. 1, see Fig. 3b. The hypsometric curve has a shape typical of an early evolutive stage (FERRO, 2006). This is apparently in contrast with the geology of the area and with the depth of the ravine, which would suggest a mature evolution. In fact, the ravine is deep and it carves the Cretaceous limestones, suggesting a long erosive process, which is not consistent with the hypsometric curve as well as with the slope of the ravine. Fig. 4b shows Rose diagram, constructed on the stretch of Torrente Lognone corresponding to the ravine, between points G-A and G-B. The diagram shows that the ravine is oriented according to NNW to SSE direction, which is roughly parallel to the Apennine.

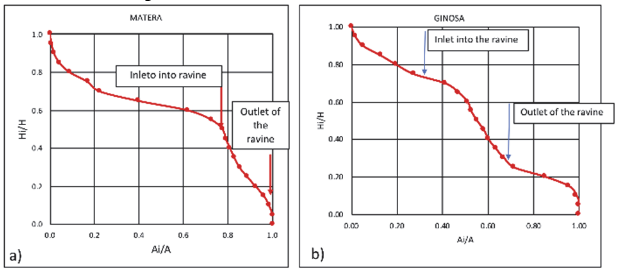

Fig. 3 - Hypsometric curve of the ravines: a) Matera, between M-A and M-B; b) Ginosa, between G-A and G-B

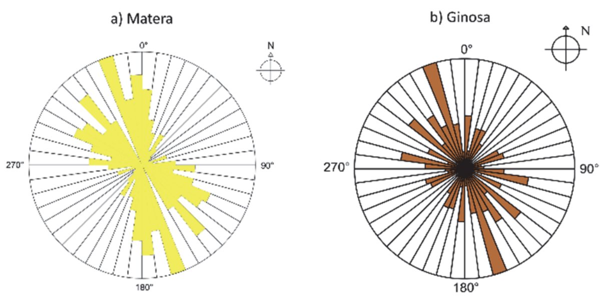

Fig. 4 - Rose diagrams: a) Torrente Gravina di Matera, between M-A and M-B; b) Ravine of Ginosa, between G-A and G-B

DISCUSSION OF RESULTS AND CONCLUSIONS

The geomorphometric analyses made on both the ravines emphasize some interesting features: the evolutive stage of the ravines segments are morphologically young and not correlated with the evolutive level of upstream and downstream stretches, which results morphologically more mature. They are well oriented according to the Apennine direction, finally the slopes of the thalwegs of the ravines are higher than the upstream and downstream stretches. These results are particularly interesting, because they evidence a plausible inconsistency with the assumption that the ravines origin is related to streamcutting erosion. In addition, the lower and mid layers of the geological formations on the slopes of ravines are Cretaceous limestones, which are notoriously more difficult to be eroded than the softer layers, the Quaternary deposits that prevail upstream and downstream the ravines. However, even if the ravines are very deep cut in the limestones, they result in a morphologically younger stage than the upstream and downstream stretches, cut in softer Quaternary deposits. Similarly, the slope of the ravines is higher than the upstream and downstream stretches, evidencing an erosional stage which is consistent with an early ongoing process, rather than with a stable evolved scenario. The prevailing directions of the ravines is a further interesting peculiarity: both the ravines are oriented according to the same direction, NW-SE, which is the same of the Apennine. They show poor meandering, which seems to be related to the irregular form of a tensile fracture since they would not be consistent with the fluvial evolution of the ravine. In fact, the meanders of both the ravines correspond to the irregular form of tensile fracture like for Matera, or to previously recognized transversal tectonic structures (Bentivenga *et alii*, 2004), like for Ginosa.

Again, these constitute evidences of a strong tectonic stress, which involved the area of the ravines. Therefore, it is possible to argue that its flanks underwent a tectonic stress, which disturbed and weakened the calcarenites, affected by some collapses, particularly visible in the ravine of Ginosa (Doglioni & Simeone, 2019).

Therefore, the presented analyses seem to suggest that the ravines were likely originated by the cracking of the boundary of Murgia, likely during Apennine orogenesis rather than by stream cut erosion. Successively, runoff started flowing through these incisions, being these minimum energy flow-paths, thus originating ephemeral streams.

REFERENCES

Bentivenga M., Coltorti M., Prosser G. & Tavarnelli E. (2004) -*A new interpretation of terraces in the Taranto Gulf: the role of extensional faulting*. Geomorphology, **60** (3–4): 383-402. Doi: 10.1016/j.geomorph.2003.10.002.

Ciaranfi N., Pieri P. & Ricchetti G. (1988) *Note illustrative alla carta geologica delle Murge e del Salento (Puglia centromeridionale)* Mem. Soc. Geol. It. **41**: 449-460

Cotecchia V. & Grassi D. (1975) - *Stato di conservazione dei "sassi" di Matera (Basilicata) in rapporto alle condizioni geomorfologiche e geomeccaniche del territorio e alle azioni antropiche*. Geol. Appl. ed Idrog., **X**: 55-105.

Cristino M.C., Doglioni A. & Simeone V. (2015) *Notes on morphological characters of ephemeral streams in Apulia region, south Italy*. In Lollino G. *et alii*. (eds), Engineering Geology for Society and Territory – Volume 3 River Basins, Reservoir Sedimentation and Water Resources. Doi: 10.1007/978-3-319-09054-2_37

Doglioni C., Mongelli F. & Pieri P. (1994) - *The Puglia uplift (SE Italy): an anomaly in the foreland of the Apenninic subduction due to buckling of a thick continental lithosphere*. Tectonics, **13** (1994): 1309-1321. Doi: 10.1029/94TC01501

Doglioni A. & Simeone V. (2019) - *Collapses in calcarenitic deposits along the sides of the Ginosa ravine in south Italy*. Applied Geology: Approaches to Future Resource Management, Springer, submitted for publication.

Doglioni A., Simeone V. & Giustolisi O. (2012) - *The activation of ephemeral streams in karst catchments of semi-arid regions*. Catena, **99**: 54-65. Doi: 10.1016/j.catena.2012.07.008

Doglioni A., Galeandro A. & Simeone V. (2015) *The generation of runoff through ephemeral streams.* Engineering Geology for Society and Territory – Volume 3 River Basins, Reservoir Sedimentation and Water Resources Eds: Lollino et Alii. doi: 10.1007/978-3-319-09054-2_36

Ferro V. (2006) – *La sistemazione dei bacini idrografici*. McGraw Hill, 700 p.

Guerricchio A. & Melidoro G., (1986) *Problematiche di geologia applicata lungo la fascia costiera ionica del Golfo di Taranto*. Atti del Convegno "Evoluzione dei litorali, problematiche relativa al Golfo di Taranto". Enea: Centro Ricerche Energia della Trisaia (Rotondella), Policoro (MT), 263-294

Simeone V., Doglioni A., Lacertosa R.M. & Sdao F. (2019) - *Environmental and Geological Characters and Stability Problems in the Historic Centre of Matera (South Italy)*. In: Shakoor A., Cato K. (eds), IAEG/AEG Annual Meeting, San Francisco – Vol. **2**: 161-168. Doi: 10.1007/978-3-319-93127-2_23

VV. AA. (2010) - *Il patrimonio geologico della Puglia*. Supplemento al n. 4/2010 di Geologia dell'Ambiente periodico della SIGEA – Società Italiana di Geologia Ambientale http://files.geocultura.net/200001428-8b8558c7f3/Volume%20patrimonio%20geologico%20Puglia%20%20def.%20Bassa%20risoluzione.pdf.