Geomorphology 134 (2011) 326–343

Contents lists available at ScienceDirect

Geomorphology

journal homepage: www.elsevier.com/locate/geomorph

Quantitative morphotectonics of the Pliocene to Quaternary Auletta basin, southern Italy

Dario Gioia [a,*], Marcello Schiattarella [a], Massimo Mattei [b], Giovanni Nico [c]

[a] Dipartimento di Scienze Geologiche, Università della Basilicata, Potenza, Italy
[b] Dipartimento di Scienze Geologiche, Università Roma Tre, Roma, Italy
[c] Consiglio Nazionale delle Ricerche, Istituto per le Applicazioni del Calcolo, Bari, Italy

ARTICLE INFO

Article history:
Received 1 October 2010
Received in revised form 14 July 2011
Accepted 16 July 2011
Available online 28 July 2011

Keywords:
Tectonic geomorphology
Basin evolution
Paleomagnetic data
DEM
Geomorphic indexes
Southern Italy

ABSTRACT

The geomorphological evolution of the Pliocene–Quaternary Auletta basin, a wide fault-bounded depression of the southern Apennines axial zone, Italy, was reconstructed using both DEM-based morphometric analysis and classical morphotectonic investigations. Morphotectonic analyses have been integrated with geological, structural and paleomagnetic data in order to reconstruct the Quaternary evolution of the area.

The Auletta basin coincides with the lower valley of the Tanagro River and is filled by Pliocene to Pleistocene marine and continental sediments. The strike of the basin is N120–130°, according to the main fault systems of the area.

Long-term landscape evolution results from interaction and feedback of geomorphic stages with the morphogenesis of erosional land surfaces alternating with tectonic pulses in which also block-tectonic rotation occurred. The ages of the morphological de-activation of such terraced surfaces have been roughly defined on the grounds of their morpho-stratigraphic relationships with Pliocene and Quaternary deposits, and better constrained by radiometric dating. Tectonic tilting has been established from morphological relationships between rotated blocks related to the activity of the Alburni fault line and the several generations of erosional and depositional land surfaces. The stratigraphic, structural, paleomagnetic and geomorphological data presented here suggest that the studied basin appears to have a more complex tectonic evolution than an extensional graben. Transtensional tectonics along NW–SE striking, listric faults of the Alburni margin system created the depression since Pliocene times, whereas extensional tectonics plays a key role in the middle to late Pleistocene morphotectonic evolution of the basin. This work demonstrates the usefulness of an integrated analysis in order to extract information on tectonic activity and landscape evolution in the Auletta basin, as an example for other study areas.

1. Introduction

In the last decade, DEM-supported morphometric analysis of landscape represents an active field of research in many geomorphological applications which aim to model surface processes. After the pioneer paper by Riley and Moore (1993), concerning the use of DEM and active tectonics, many contributions came from areas with different geological settings (Delcaillau, 2001; Jordan, 2003; Schoenbohm et al., 2004; Korup et al., 2005; Frankel and Pazzaglia, 2006; Peters and van Balen, 2007; Pérez-Peña et al., 2010; among others). Nevertheless, just a few cases concern southern Italy (Amato et al., 2003; Molin et al., 2004; Capolongo et al., 2005; Martino et al., 2009), an area affected by high vertical mobility and widespread seismicity. The aim of this work is to extract information on tectonic activity and landscape evolution of the Auletta basin, a wide structural depression of the axial zone of the southern Apennines (Fig. 1), by means of such an approach together with more traditional tools for determining the structural and tectonic geomorphology. To achieve this goal, a detailed quantitative analysis of topography combined with the study of drainage patterns was performed. Morphotectonic analysis has been integrated with geological, structural and paleomagnetic data in order to reconstruct the Quaternary evolution of the Auletta basin.

Quantitative analysis of the landscape has been carried out on a topographic dataset derived by the interferometric SAR data acquired during the SRTM mission (Farr and Kobrick, 2000; Rabus et al., 2003). The main advantage of SRTM digital topographic maps is that it meets the requirements for a homogeneous reliable DEM fulfilling DTED-2 specifications (Bhang et al., 2007). Such a consistency overcomes the limitations of other global elevation datasets (for instance, ETOP05, GTOPO30, GLOBE) which are constructed using various techniques and datasets, and so having different accuracies in different regions. The development of global high resolution DEMs is an active field in the research community working on radar interferometry. Recently

* Corresponding author.
E-mail addresses: dario.gioia@unibas.it, gioiadario@libero.it (D. Gioia).

0169-555X/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.geomorph.2011.07.009

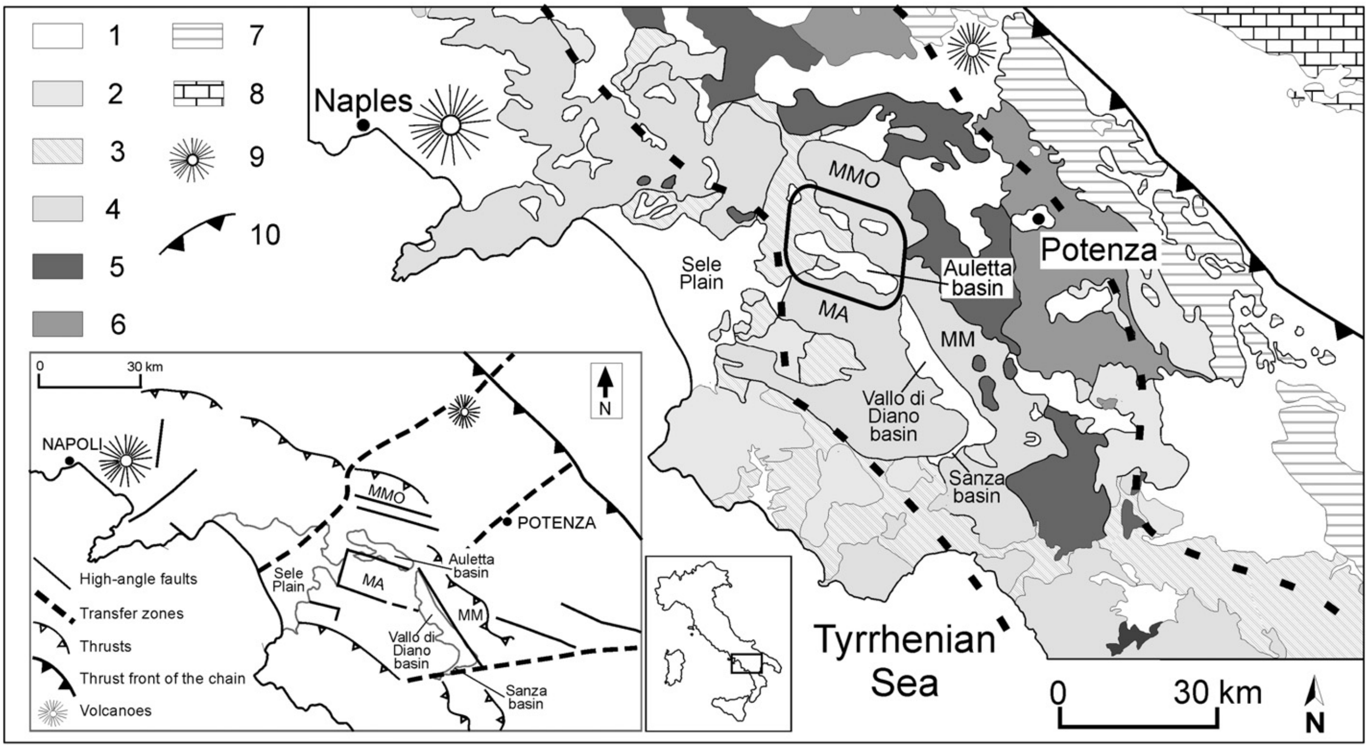

Fig. 1. Geological sketch map of the southern Apennines. The Auletta basin is represented in the box. Dashed lines indicate the borders of the inner, axial and outer belts. MM: Maddalena Mts.; MA: Alburni Mts.; MMO: Mt. Marzano–Mt. Ogna group. Legend: 1) Pliocene to Quaternary clastic deposits and volcanic products; 2) Miocene syntectonic deposits; 3) Cretaceous to Oligocene ophiolite-bearing internal units; 4) Mesozoic–Cenozoic shallow-water carbonates of the Apennines platform; 5) lower–middle Triassic to Miocene shallow-water and deep-sea successions of the Lagonegro-type Monte Arioso unit; 6) Mesozoic to Miocene deep-sea successions of the Lagonegro-type Groppa d'Anzi unit; 7) Cretaceous to Miocene deep-sea successions of the Lagonegro-type Campomaggiore unit; 8) Mesozoic–Cenozoic shallow-water carbonates of the Apulian platform; 9) volcanoes; 10) thrust front of the chain. In the frame: tectonic sketch map of the Campania–Lucania Apennines with high-angle faults of the studied area (mainly represented by N120° ± 10° left-lateral strike-slip and oblique faults, E–W- to NE–SW-directed transfer faults, and by the N150°–160°-striking Vallo di Diano normal fault).

the TanDEM-X spaceborne mission was planned by the German Space Agency to generate world-wide, consistent, high-precision Digital Elevation Models corresponding to the DTED-3 standard. The SRTM DEM is available on a 90 × 90 m spatial grid and with less than 16 m absolute vertical accuracy (Falorni et al., 2005; Bhang et al., 2007). Spatial resolution of DEM represents a modern facility in analyzing terrain features as large as 16,000 to 24,000 m^2, thus also permitting an appreciation of outcrop-scale morphological details (Kervyn, 2001).

We calculated statistical properties of landscape and estimated some geomorphic indices that reflect the interaction between erosional and tectonic processes. In addition, a detailed morphotectonic analysis based on field survey and aerial photo-interpretation allowed us to distinguish several orders of erosional land surfaces both in the basin and surrounding mountains, which have been used as morphological and chronological markers of Quaternary regional uplift and tectonic block tilting. In areas characterized by a complex evolutionary history such as southern Italy, the analysis of these geomorphological features related to former erosion base-levels represents the best approach to assess long-term landscape evolution and to estimate uplift and erosion rates (Schiattarella et al., 2003; 2006; Martino et al., 2009).

2. Study area

The Auletta basin (Fig. 2) is a N120–130°-trending fault-bounded depression located in the axial zone of southern Italian Apennines (Amato et al., 1992; Ascione et al., 1992; Gioia and Schiattarella, 2010). This sedimentary basin partly coincides with the hydrographical catchment of the lower valley of the Tanagro River, which longitudinally crosses the entire Auletta basin after having run through the Vallo di Diano valley (Fig. 1), representing the upper portion of the whole drainage area. Additional data for various comparisons come from the Sanza basin (Fig. 1), a south-western lateral branch of the Vallo di Diano valley filled by mid-Pleistocene lacustrine sediments, at present crossed by a stream not flowing into the Tanagro River system.

The Auletta basin is filled by a very thick Pliocene–Pleistocene marine to continental clastic succession (Fig. 3) characterized by several orders of land surfaces consisting of both erosional and depositional landforms. Several orders of fluvial terraces are, in fact, arranged along the present-day main rivers, whereas older erosional surfaces cut the Pliocene clastics of the basin at different heights. In addition, remnants of regional-scale, flat paleo-landscapes and younger, less extended, gently dipping erosional surfaces characterize the top and slopes of carbonate mountains. The relationships of such landforms with Pliocene to Quaternary faults and deposits provided consistent information on mid- and long-term landscape evolution of the study area.

The meaning of the structural setting of the Auletta basin and the stages of its tectonic evolution are still debated. Based on stratigraphic and morphotectonic analysis, Ascione et al. (1992) and Amato et al. (1992) suggest a complex tectonic evolution of that basin, with alternating sequences of strike-slip and extensional faulting during Quaternary times. Recently, Barchi et al. (2007) and Amicucci et al. (2008) interpreted the Auletta basin as a simple extensional graben, mainly on the grounds of seismic data. Apart from providing a new contribution to solve the problems related to the structural genesis and evolution of the Auletta basin, the morphotectonic approach used here allowed us to better constrain both the whole landscape history of the basin and the rate and timing of activity of the basin-border faults.