LONG TERM VS. CURRENT VERTICAL MOTIONS IN THE NORTHERN CAMPANIA PLAIN AREA (SOUTHERN ITALY)

A. Ascione[1], S. Nardò[1], C. Cerrone[1], A. Santo[2], S. Mazzoli[1]

[1] *Dip. di Scienze della Terra, dell'Ambiente e delle Risorse - DiSTAR, Università degli Studi Federico II, Napoli, Italy*
[2] *Dip. di Ingegneria Civile, Edile e Ambientale - DICEA, Università degli Studi Federico II, Napoli, Italy*

Introduction. The Campania Plain is an about 35 km wide and 60 km long coastal graben that includes the volcanic districts of Campi Flegrei and Vesuvius (Fig. 1). To date, most of the knowledge on the geological history of the Campania Plain graben, and particularly of its northern part, is inferred from subsurface data, while very little of such knowledge is based on surface geology information. This is mainly due to the widespread occurrence of recent pyroclastic/ volcaniclastic deposits blanketing the Plain and its borders. In order better constraining the Quaternary tectonic evolution of the northern part of the Campania Plain graben, and particularly the late Quaternary vertical motions, we are carrying out a tectonic geomorphology study on the north-eastern border of such area. The new information is combined and compared with satellite interferometry data analyses, with the aim of reconstructing the current deformation framework and its relationships with Quaternary structures.

Geological setting. The Campania Plain is the largest in the peri-Tyrrhenian basins that developed since the Early Pleistocene along the southwestern margin of the southern Apennines as a response to extension active in the southern Tyrrhenian basin (e.g. Sartori, 1990; Savelli and Schreider, 1991). As it is shown by large amounts of surface, subsurface and offshore data, the southern Apennines peri-Tyrrhenian grabens share a common, large-scale structural setting. Roughly NE-SW trending fault systems located at the northwestern boundaries of the grabens control asymmetrical - northward thickening - basin fills, and downthrow the carbonate successions, exposed in the surrounding horst blocks, down to depths of 3000 - 4000 m (e.g. Bartole *et al.*, 1984; Moussat *et al.*, 1986; Mariani and Prato, 1988; Argnani *et al.*, 1989; Bruno *et al.*, 1998; Florio *et al.*, 1999; Milia *et al.*, 2003; Caiazzo *et al.*, 2006; Milia and Torrente, 1999). Geophysical data show that the Campania Plain is also dissected by S to SW-dipping fault systems (e.g., Florio, 1998; Bruno *et al.*, 2000; Milia and Torrente, 2013, 2015) that bound distinct sub-basins.

Strong Quaternary subsidence of the northern part of the Campania Plain graben, is testified by Lower Pleistocene shallow marine and transitional (delta facies) deposits drilled down

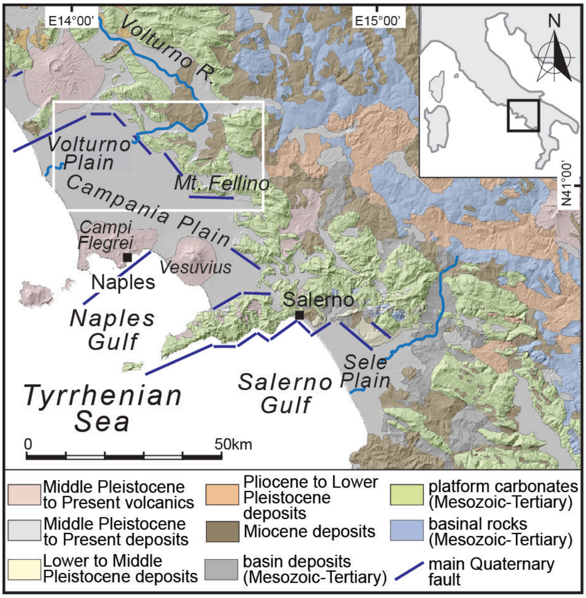

Fig. 1 – Simplified geological map of the northern part of the southern Apennines Tyrrhenian margin, showing the coastal grabens and the main Quaternary faults at their boundaries. The white frame indicates location of the study area.

to 3000 m below sea level (ViDEPI, 2009). Pyroclastic and lava deposits drilled around and below 2000 m depths in deep wells (ViDEPI, 2009) testify to early volcanism dating back to the Early Pleistocene (Di Girolamo *et al.*, 1976). More recent, intense explosive volcanism occurred since 400 ky ago (Rolandi *et al.*, 2003), and climaxed with the emplacement of the Ignimbrite Campana pyroclastic flow deposits at 40 ky (De Vivo *et al.*, 2001). Abundant primary and reworked pyroclastic inputs largely contributed to filling of the Campania Plain since the Middle Pleistocene, probably accompanied by slowing of subsidence (Brancaccio *et al.*, 1991), which however continued in the last 100 ky (Romano *et al.*, 1994; Santangelo *et al.*, 2010). More recent (< 40 ky) vertical displacements at the northern boundary of the Campania Plain are testified by geomorphological information and subsurface stratigraphy data (Romano *et al.*, 1994; Cinque *et al.*, 2000).

Materials and methods. The tectonic geomorphology study has been carried out by the analysis of detail-scale topography data (Regione Campania 1:5000 scale maps; LiDAR images) and field surveys. The latter were carried out along the eastern margin of the northern Campania Plain, were several Quaternary shallow marine, alluvial and pyroclastic units have been identified. The Quaternary stratigraphy study of the Plain margin has been integrated with subsurface data obtained by several published and unpublished borehole logs.

Satellite interferometry data are based on phase comparison of SAR images acquired at different times and perspective views. Permanent Scatterers Interferometric Synthetic Aperture Radar (PS-InSAR; Ferretti *et al.*, 2001; Vilardo *et al.*, 2009) is one of the latest applications of SAR time series data analysis. Permanent Scatterers are radar image points on the ground that show stable interferometric phase behaviour for wide look-angle variations over time, and are used to estimate the progressive sub-vertical motion of the ground surface. In this study, we have used satellite interferometry data spanning over an about 20 year long time span, i.e. PS datasets by ERS 1 + 2 (1992 - 2000) and ENVISAT (2002 - 2010), obtained by Ministero dell'Ambiente, della Tutela del Territorio e del Mare (MATTM). PS-InSAR datasets have been analysed through geostatistical spatial analysis in order to construct deformation maps for the time windows covered by the two datasets. The use of a clustering geostatistical methodology has allowed identifying clusters of kinematically homogeneous PS with reference to mean PS velocity values. The spatial analysis identifies statistically significant elements using the Anselin Local Moran's I statistic. The calculated indexes show whether the apparent similarity (spatial clustering of high/low values) or dissimilarity (spatial outliers) is more pronounced than one would expect in a random distribution. Following Perrone et al. (2013), clues to the interpretation of single kinematic domains identified through the statistical analysis, and boundaries between kinematic clusters, have been provided by geological/geomorphological information.

Results. The field surveys and the geomorphological analysis provide new data on the early stages of development of the northern Campania Plain and late Quaternary faulting. The

Fig. 2 – View from the SE of the marine terrace at about 200 m a.s.l. (indicated by the white arrows) located at the eastern boundary of the Campania Plain, at the termination of the Mt. Fellino ridge (in the foreground, location in Fig. 1).

identification of uplifted marine terraces in the 200 m to 50 m elevation range (Fig. 2) allows outlining the perimeter of the Plain in the early stages of its formation. Well-preserved marine terrace deposits are exposed in several quarries located along the southern slope of Mt. Fellino (Fig. 1). The outcrops show a several tens of metres thick transgressive-regressive succession consisting of beach conglomerates, fossiliferous arenites and sands, passing upwards to alluvial fan and slope deposits that rest onto wide wave-cut terraces, and are buried beneath younger alluvial fan and slope deposits. The marine-continental succession is dissected by N-S and NW-SE trending extensional faults, and is lowered beneath the Holocene alluvial plain by a major E-W trending fault system (Fig. 3). Faults showing similar trends and young activity are identified by geomorphological evidence and subsurface stratigraphy information more to the north, where they control the perimeter of the Holocene Volturno River alluvial plain.

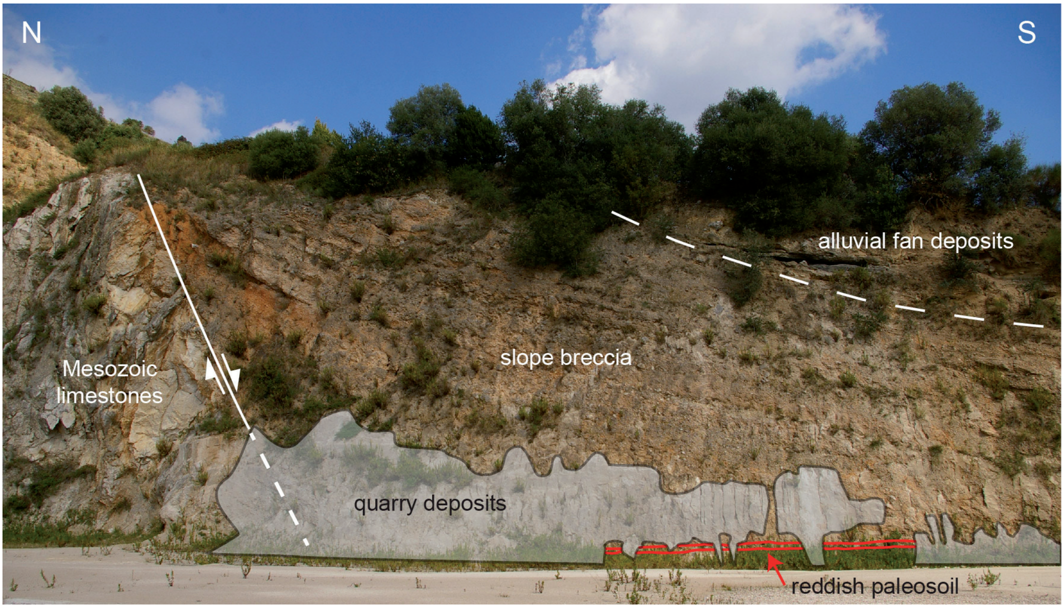

Fig. 3 – Slope deposits offset by a roughly E-W trending fault, in the southern slope of the Mt. Fellino ridge. The slope deposits overlie shallow marine deposits (downfaulted below the ground surface) and are unconformably covered by alluvial fan deposits.

Current vertical deformation in the study area is inferred from the analysis of PS-InSAR datasets for the 1992-2010 time span. In particular, the analysis shows that the pattern of homogeneous kinematic domains follows that of faults showing evidence of recent activity in the Volturno River alluvial plain, while a more complex pattern is observed in the eastern part of the Campania Plain. The integrated datasets provide a comprehensive picture of the recent and active deformation scenario in this densely populated area, and of the time-space migration of extensional fault activity.

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