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LATE QUATERNARY GEOLOGY AND MORPHOEVOLUTION OF THE VOLTURNO COASTAL PLAIN, SOUTHERN ITALY

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ABSTRACT: The Volturno alluvial-coastal plain is a relevant feature of the Tyrrhenian side of southern Italy. Its plan-view squared shape is due to Pliocene-Quaternary block-faulting of the western flank of the chain. The Quaternary infill of the Volturno plain has been here studied by means of well data. An asymmetrical shape of its ancient morphology – with a steeper slope toward the north-west border – and the lack of coincidence between the present course of the Volturno River and the main buried bedrock incision are significant achievements of this study. Landforms analysis completed the frame of the recent evolution of the plain.

KEYWORDS: Well log correlation, Late Quaternary evolution, Volturno coastal plain**,** southern Italy

1. INTRODUCTION

The alluvial-coastal plain of the Volturno River is a relevant feature of the Tyrrhenian side of the Italian south-Apennine chain. In a planimetric view, it has a roughly quadrangular shape, due to Pliocene-Quaternary block-faulting of the western flank of the orogen after the Tertiary extension of the back-arc basin. The plain is in fact bordered by the structural highs of Mt. Massico and Caserta Mts to the north-west and north-east, respectively, and by the Ischia Island - Phlegraean Fields volcanic alignment to the south-east. This area has already been studied and the state-of-art literature is proposed in Santangelo et al. (2017). Several authors investigated the infill stratigraphy of such a structural depression by means of borehole analysis (Romano et al., 1994; Barra et al., 1996; Santangelo et al., 2010; Amorosi et al., 2012; Sacchi et al., 2014). The absence of Pliocene marine deposits in the deepest boreholes suggests that the plain was above sea level during late Tertiary times. Anyway, during the Quaternary, the tectonic subsidence favoured the accommodation of more than 3000 m of marine, transitional, and alluvial sediments (Santangelo et al., 2017, and references therein).

During the first part of the Late Pleistocene, the filling of plain was helped by the onset of volcanic activity from different sources. At about 39 ka B.P. the huge eruption of Campanian Ignimbrite (CI) occurred (Rolandi et al., 2003, and references therein) and uniformly covered the entire plain with a pyroclastic flow deposit tens of meters thick. Tephra deposits interbedded with sediments provide important stratigraphic and geochronological markers. In the second part of the Late Pleistocene, the whole plain emerged due to the subsidence rate reduction and the contemporary last glacial regression. During the Holocene, the plain underwent diffuse flooding in concomitance with the peak of the post-glacial transgression. The subsequent decrease of the sea level rise favoured coastal progradation and development of lagoon and swamp systems several kilometres inland from the present coastline (Barra et al., 1996; Amorosi et al., 2012).

In this work, we present the results of an extensive and detailed stratigraphic analysis of the Late Pleistocene - Holocene infill of the Volturno plain based on almost 700 well logs generally not exceeding 30 m of depth from the ground level. Further, the geomorphological analysis of the Quaternary elements of the landscape - such as coastal features and foothill-plain connecting landforms - has completed the frame of the recent evolution of the plain. The aim of this study is to define a detailed palaeoenvironmental and stratigraphic reconstruction after the CI eruption and the role of tectonic and eustatic forcing in the evolution of the coastal plain.

2. MATERIAL AND METHODS

A subsurface lithostratigraphic dataset based on 680 wells drilled in the plain was integrated by geological cartography and field survey. Detailed sedimentological analysis and facies interpretation were acquired from literature (e.g. Romano et al., 1994; Amorosi et al., 2012) and other unpublished data. All these data have constituted the core for the reconstruction of a Quaternary stratigraphic succession. Such a task has needed an effort to homogenize data from different sources by using log charts and their precise positioning in a GIS. Subsurface data have been used to realize geological cross-sections and a map of roof of the CI by GIS interpolation techniques. Age determination for stratigraphic correlations is based on constraints of volcanic and marine deposits from literature (see references in Results).

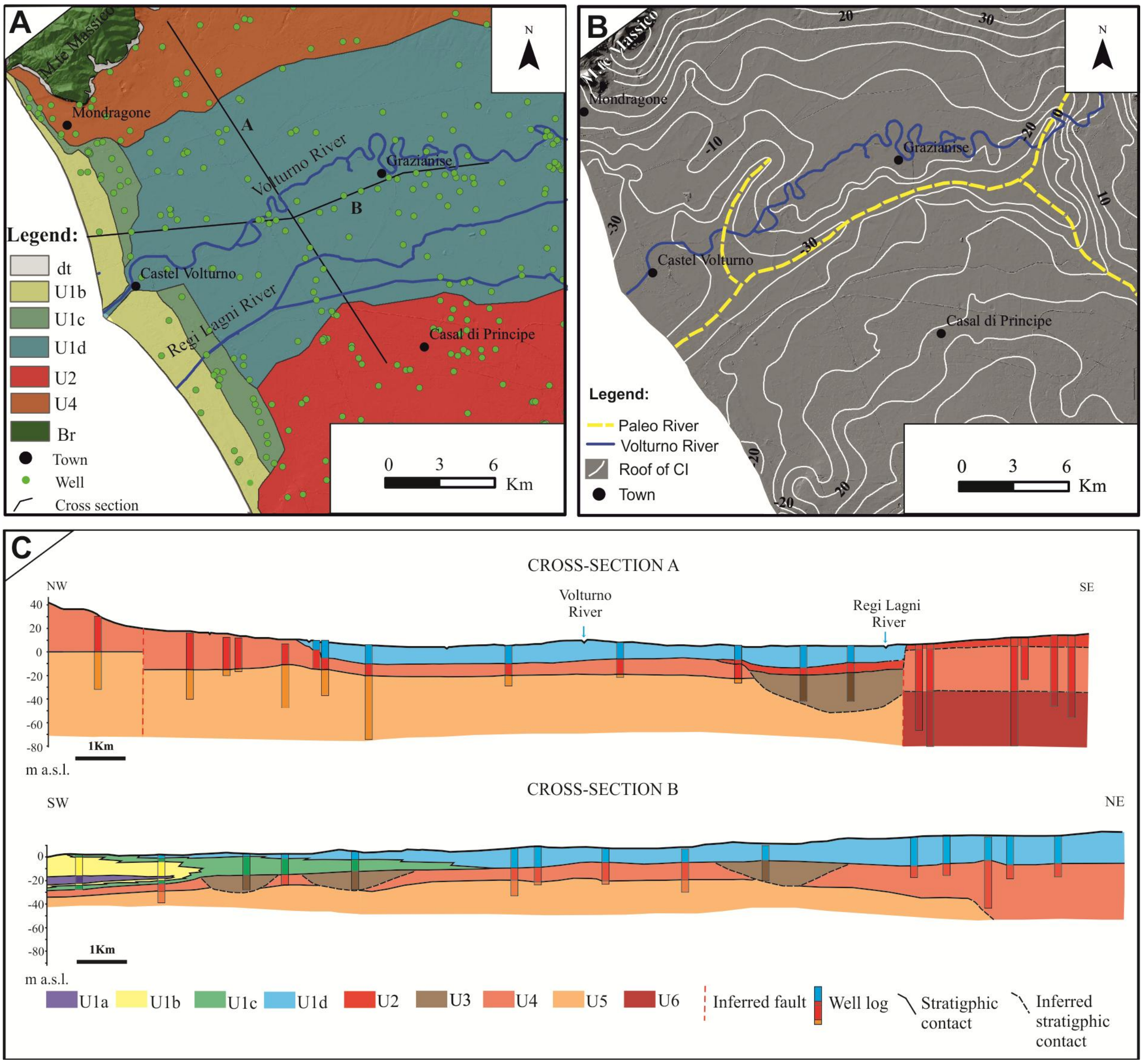

Fig. 1- A) Simplified geological map of the Volturno Plain area. Legend: Br: pre-Quaternary bedrock; U4: Campanian Ignimbrite (Late Pleistocene); U2: depositional unit composed of both volcaniclastic sediments and pyroclastic units (Giugliano Ignimbrite and Neapolitan Yellow Tuff, Late Pleistocene); U1d: alluvial deposits (Holocene); U1c: back-dune ridge deposits (Holocene); U1b: beach-dune ridge deposits (Holocene); dt: slope deposits (Late Pleistocene – Holocene). B) Contour map of the Campanian Ignimbrite roof and inferred course of the palaeo-Volturno River. C) Geological cross-sections obtained from well logs (30x vertical exaggeration).

3. RESULTS

The stratigraphic architecture of the Late Quaternary Volturno plain infill has been reconstructed and seven lithostratigraphic units based on homogeneous sedimentological and palaeontological criteria have been individuated (Fig. 1). Hereinafter, they are briefly described from the younger to the older one, including their stratigraphic contacts with the adjacent units. Stratigraphic and chronological constraints enable us to propose a general chronology and to attribute age intervals for each unit.

Unit 1 - Holocene deposits (12-0 ka) represent a complex and articulated sedimentary body progressively formed from sea to the land by four sub-units characterised by lateral transitional contacts: prodelta (U1a, clays and silts with euryhaline fossils), beach-dune ridge (U1b, well sorted sands with marine shells), lagoonal-swamp (U1c, clays with organic matter and freshwater gastropods) and alluvial (U1d, pedogenised clays and silts with sand lens) deposits. The U1 bottom is normally the U4 (CI), which also represents its lateral contact towards north and east. The Pleistocene alluvial (U3) and pyroclastic (U2) deposits, represent a very discontinuous substrate for this unit. By integrating subsurface and literature (Romano et al., 1994; Barra et al., 1996; Amorosi et al., 2012, Sacchi et al., 2014) data, the U1 can be considered as Holocene transgressive-regressive depositional complex.

Unit 2 - Pyroclastic flow and fall deposits and volcanoclastic sediments (23-12 ka B.P.) represented by the Giugliano Ignimbrite (GI; age 23-18 ka B.P., after Rolandi et al., 2003) below and the Neapolitan Yellow Tuff (NYT, ~12 ka B.P. in age, Rolandi et al., 2003) above, deposited in subaerial conditions, and by their reworked deposits. The U2, bounded at the bottom by a palaeosol, mostly occurs in the southern sector of the Volturno plain above the CI (U4).

Unit 3 - Late Pleistocene alluvial plain deposits (29-39? ka B.P.) occur as channelled fills (gravels, sands passing upward to silts with peat intercalations) of fluvial palaeochannels incised in the U4. It is highly discontinuous and covered by U1 and U2 (radiometric age 37 ka B.P., after Amorosi et al., 2012).

Unit 4 - Campanian Ignimbrite (CI, 39 ka B.P.). Pyroclastic deposits, laterally continuous, attributed to a highly explosive eruption of the Phlegraean Fields (Rolandi et al., 2003 and references therein), covering the entire ancient plain with an articulate palaeotopography (fig. 1B). CI erosional roof shows progressively higher depths (about -35 m b.s.l.) towards the centre of the plain.

Unit 5 - Coastal-marine and transitional deposits with alluvial episodes (~?50-39 ka B.P.). Yellowish and grey sands with molluscan shells, and clays with local peat lens represent the main lithology of this unit, which is the substrate of the CI and U3 at depth more than -35 m b.s.l. in central plain and above sea level in proximity of border relief.

Unit 6 - pre-CI volcaniclastic deposits (~50-105 ka B.P.) erupted by Roccamonfina and Phlegraean Fields and locally separated by thin palaeosols are included in this unit, which appears more discontinuous in the northern than in central and southern sectors of the plain. The U6 rests upon U7 by an erosional contact and is covered by the U4 and U5. Its age is based on radiometric (~50-105 ka B.P.) and palaeoenvironmental constraints (Romano et al., 1994; Santangelo et al., 2010).

Unit 7 - Coastal-marine and transitional deposits (~105-130 ka B.P.) are composed of fossiliferous clays and silts interbedded with yellow sands or fine gravels (U/Th dating ~126 ka B.P., after Romano et al., 1994; >105 ka B.P., after Santangelo et al. 2010). This unit is continuous and the deepest one, placed between 20 m a.s.l. in proximity of border relief and between -20 and -90 m b.s.l., on the left and right sides of the Volturno River, respectively. These deposits cover lava bodies in the southern sector of the plain ascribed to the buried Parete volcano.

Stratigraphic relationships of the above described units, partly represented in the geological cross-sections of figure 1C, suggest a complex Late Quaternary sedimentary evolution starting from the deposition of the CI, which represents the substratum of Late Pleistocene-Holocene sediments. The subsurface channelized buried landforms in the CI substratum testifies the palaeo-Volturno river incision as a consequence of MIS 2 sea level low stand. The facies analysis of Holocene units indicates that the Volturno River channel shifted from SE to the present-day position (fig. 1B and fig. 1C, cross-section A). The deposition of the Holocene Unit 1 (coastal-lagoonal-swamp-alluvial sedimentary body) testifies the rapid marine transgression recorded by the progressive onlap of the beach-dune ridge sands on continental deposits. The maximum landward shift of transgressive sands can be estimated of about 3-4 km on average respect to the present-day position, so as the palaeo-position of the back-barrier environments is further inland.

4. DISCUSSION AND CONCLUSIONS

The significant achievements of this research are: a) a better knowledge of distribution and evolution of the coastal-marine to continental palaeoenvironments of the Volturno plain during the Late Quaternary; b) the reconstruction of base and roof of the Campanian Ignimbrite that – integrated by geomorphological analysis of the Quaternary elements of the landscape - has allowed upgrading the 3D shape of the Volturno plain palaeomorphology before the deposition of Late upper Pleistocene - Holocene sediments. In fact, it is now possible to infer an asymmetrical shape of the ancient morphology of the plain - with a steeper slope toward the north-west border (i.e. Mt. Massico morphostructural high) - and the lack of coincidence between the present course of the Volturno River and the main buried bedrock incision.

Based on these data, it is possible to affirm that the Late Quaternary evolution of the Volturno plain has been mainly controlled by eustatic changes of sea level during which intense volcanic activity occurred. The rapid sea level rise after the last glacial maximum is testified by a backstepping depositional architecture of the Holocene delta-coastal and lagoonal-swamp system directly on late Pleistocene incised palaeo-Volturno plain. The maximum ingression of the shoreline was about 3-4 km inland. Starting from about 5 ka B.P., in response of the decreasing rate of sea level rise, a prominent coastal and delta system progradation and alluvial aggradation is documented from well and field data. However, taking into account also the subsidence data (Aucelli et al., 2016; Matano et al., 2018), Late Quaternary tectonics should be considered active to produce the asymmetry the CI roof as well as the lateral migration of the Volturno River during this time interval. Such a trend seems to continue in more recent times, as testified by the location of a thick alluvial succession (Fig. 1C, cross-section A) south of the present-day main channel.

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