Quaternary International xxx (2016) 1–16

Contents lists available at ScienceDirect

Quaternary International

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

# Geomorphological features of the archaeological marine area of Sinuessa in Campania, southern Italy

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ARTICLE INFO

*Article history:*
Available online xxx

*Keywords:*
Coastal geomorphology
Geoarchaeology
Sedimentology
Sea level change
Italy

ABSTRACT

Submarine surveys carried out since the '90s along the coastland of Sinuessa allowed us to draw up a geomorphological map with archaeological findings. Along the sea bottom, 650 m off and −7 m depth, a Campanian Ignimbrite bedrock was detected: dated ~39 kyr BP, its position is incompatible with the current sea level. Towards the northern edge of the shoal, a depressed area with 24 cubic elements in concrete was surveyed. These artefacts (*pilae*) are typical of Roman maritime structures widespread along the southernmost Phlegrean coast. Beachrocks and accessory landforms at the same depth of bedrock suggest that this was emerging and attended by man in Roman times, even for activities related to port facilities. Submerged palaeo-channels, in alignment of current watercourses on the mainland, dissect the shoal. These channels were moulded in subaerial environment during Würm glaciation, following the tuff deposition, and then were drowned by sea-level rise. The northernmost channel, next to the *pilae*, likely allowed transit and manoeuvring of Roman ships. The discovery along the seabed of a large stump of lead anchor, hundreds of Roman amphorae and fragments, as well as of a depression of millstone, confirm this finding. Probably the sinuous physiography favored the choice of this site for the docking of Sinuessa, as sheltered from storms.



## 1. Introduction

Ground vertical motions along the coast could activate strong erosional processes and the loss of invaluable archaeological heritage. Their analysis represents an useful element to define coastal zone hazards and management (De Pippo et al., 2008, 2009). In submerged archaeological sites these phenomena can be investigated by reconstructing the ancient coastlines, based on the identification of geomorphic elements moulded during the interglacial sea-level stands (Pirazzoli, 1987, 1991, 1993). Such features, when displaced at different heights with regard to their original genetic contexts, have also furnished important indications about tectonic activity (Flemming, 1969; Flemming and Webb, 1986; Ferranti et al., 2005).

In particular, the colony of Sinuessa is the only and most significant underwater archaeological site along the northern coast of Campania, near the border with Latium, about 40 km north of the other submerged sites of Torregaveta and Pozzuoli Bay. The presence of roads and maritime structures of Roman age, still visible along the coastland of Sessa Aurunca, including in the Caserta district, stimulated geomorphological researches also in the submerged area since the nineties (Cocco et al., 1996a, 1996b).

New investigations have been triggered by the presence of an ancient Roman road, paved in limestone, perpendicular to the shoreline (*i.e.* E–W oriented), which ends abruptly, disappearing under the sand of the coastal dune ridge (close to the Baia Azzurra residential complex). In the facing submerged area was detected a stretch of road along the same direction as well as archaeological remains attributable to artefacts and port facilities, possibly related to coastal appliances and activities of the colony seaward. The roadway on the mainland is a branch to the coast of the ancient Via Appia, built starting in 312 BC by the consul Appio Claudio, who

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http://dx.doi.org/10.1016/j.quaint.2016.04.019
1040-6182/

linked the colony *Minturnae* (a fluvial harbour in southern Latium) with Rome and the settlements of southern Italy. The founding of the Latin colony of *Suessa Aurunca* (313 BC), near the Roccamonfina volcano, and the creation of the two small Roman colonies of *Minturnae* and *Sinuessa* in 296 BC, after the raids of Samnites in the *Ager Falernum*, represent the key stages of the process for the political and military control of this territory, originally dominated by the Auruncis (313 BC: destruction of the Auruncis population; see Pagano, 1974; Coarelli, 1993; Crimaco, 1993; Gasperetti, 1993; Bellini, 2007). *Minturnae* and *Sinuessa* were twin colonies. The latter is located in the present-day narrow coastal strip between the northwestern offshoots of Mt. Massico and the Tyrrhenian Sea. Both were small defenses or coastal forts that were tasked to control the territory and the coast; especially the first colony controlled the river mouth of *Liri* (the current Garigliano River) while the second one the coastal access to the Campania Plain (*Ager Campanus*).

Around 174 BC, Sinuessa become a big city thanks to the production and trade of wine throughout the Mediterranean as well as a refined holiday location for the presence of thermal baths. The *Aquae Sinuessanae*, whose evidences are still present, are sulphurous waters whose facilities were present in the coastal strip between the slopes of Mt. Cicoli and the beach. The history of the city seems to stop around the III century AD together with its port facilities (Crimaco, 1993). Finally, the term Sinuessa, *Σινουεσσα* or *Σινυεσσα* in ancient Greek, likely derives from the composition of the Akkadian verb *ṣênu*, meaning "load the boat" as well as "set sail", and the noun *aṣû* (from *apsû*, "deep water") which is "to go out", "exit", referred to an outlet of channel (Semerano, 2003). The subsequent Latin word *sinus* preserves the meaning of "sailing", but also means "bend, fold, where the earth does fold" (Strabone, 64 BC–19 AD, in Jones, 1917–1932). Therefore, the etymology of Sinuessa recalls the ancient morphology of the local waterscape: a bay, with a channel, used as docking.

## 2. Regional setting

The study area is located in the southernmost stretch of the Gaeta Bay, at the foot of the western termination of the carbonate ridge of Mt. Massico (Fig. 1). The bay describes a wide littoral bend extending along southern Latium and northern Campania, and shows homogeneous coastal characters until the southern boundary formed by the active volcanic district of Phlegrean Fields (De Pippo et al., 2008, 2010; Barra et al., 2010; Pennetta et al., 2015). This bay is bordered inland by the Aurunci Mts and by the mountain range close to the town of Caserta, both made of Mesozoic carbonates. The Aurunci Mts extend almost to the sea, north of Gaeta, before retreating – through systems of normal faults – several kilometers to the south, so creating the conditions for the development of the *graben* in which the coastal plain of Garigliano River extends, at whose southwestern margin the study area is located. The mountains of Caserta, more backward than the Aurunci Mts, led to the genesis of the wider *graben* in which the coastal plain of Volturno River was formed in the same way. The tectonic depressions reflect a *horst*-and-*graben* structure, typical of the western flank of the Apennines in Campania. Actually, in the floodplains of Garigliano and Volturno rivers the thickness of the sedimentary sequence and volcanic units are respectively of about 700 and 3000 m (Ippolito et al., 1973; Mariani and Prato, 1988).

The two plains overlooking the Gaeta Bay and are divided by the ridge of Mt. Massico (813 m a.s.l.), a morphostructural high transversal to the shoreline (Carrozzo et al., 1986). It constitutes the outcrop of the carbonate substratum of the structural depressions and consists of a limestone dolomite sequence (Cestari, 1964, 1965; Vallario, 1964, 1966; Bergomi et al., 1969). Miocene sediments mainly outcrop along the southwestern slope of Mt. Massico and consist of limestones as well as terrigenous sequences with different *facies* (Cestari, 1964, 1965; Vallario, 1964, 1966; Sgrosso, 1974). This ridge is bordered to the northwest and southeast by counter-Apennine normal faults (NE–SW), Middle–Late Pleistocene in age (Radicati di Brozolo et al., 1988; Ballini et al., 1989; Bruno et al., 2000). The southwestern sector is affected by a NW–SE directed vertical fault. The seismic sections of Campania offshore (Bruno et al., 2000) and the positive magnetic anomalies (Carrozzo et al., 1986) confirm that the *horst* structure of this mount also extends towards the sea, in the sea bottom substratum, with an amplitude of about 7 km, and that is bounded by sub-vertical faults. Therefore, since the Mt. Massico structure is more uplifted than the downthrown margins that form the substrate of the plains, a minor coastal plain is outlined, partially falling in the territory of Sessa Aurunca and Mondragone (archaeological site of Sinuessa), likely differentiated from those of the two major plains of Garigliano and Volturno rivers.

Starting from the Late Pliocene, along the fault systems at the margins of these depressions an intense volcanic activity occurred, developing the Roccamonfina Volcano (Radicati di Brozolo et al., 1988; Ballini et al., 1989), the Phlegrean Fields caldera (Di Girolamo et al., 1984), and Mt. Somma-Vesuvius volcanic complex (Alessio et al., 1974). During the Pliocene–Pleistocene time span the *graben*-like structure of the Campania Plain was filled by marine, continental and transitional sediments, interbedded with pyroclastic and lava products erupted from the above mentioned volcanoes (Delibrias et al., 1979; Bernasconi et al., 1981; Capaldi et al., 1985; Di Girolamo et al., 1988).

Among the Quaternary deposits also volcanic units occur both of Roccamonfina, distributed along the northern slopes, and the Phlegrean Fields districts. The latter, attributed to the Campanian Ignimbrite (De Vivo et al., 2001), mainly outcrops along the southern slopes and subordinately along the northern ones (Bergomi et al., 1969). This volcanic formation is the gray coherent *facies* of the tuff erupted ~39 kyr BP in the volcanic district of the Phlegrean Fields, 45 km further south.

Subsidence in the coastal strip has been active since Tyrrhenian transgression (~125 kyr BP), with average rates around 2 mm/yr (Bordoni and Valensise, 1998). At the end of the Tyrrhenian and up to ~90 kyr BP, Mt. Massico was a peninsula which separated two gulfs: to the north, one currently occupied by the plain of the Garigliano River, and to the south the other by the Volturno River. Starting from ~90 kyr BP sea level gradually lowered down to the present depth of −120 m ~18 kyr BP (Last Glacial Maximum – LGM; Yokoyama et al., 2000; Lambeck and Purcell, 2005). In this time range, ~39 kyr BP the Campanian Ignimbrite formation emplaced and dense ignimbritic fluxes reached the study area. These fluxes spread northward, filling the Volturno *graben* with thickness up to about 50 m in the depocenter. Subsequently, these flow deposits were covered by recent sediments, while Campanian Ignimbrite frequently outcrops along the foothills of carbonate reliefs, sometimes even tectonically displaced. The carbonate ridges, including that E–W oriented of Mt. Massico bordering the plain to the north, morphologically hindered the flows. A significant proportion of fluxes deposited along the southern slope of the mount, while a minor one bypassed it. Along the western foothills, NW–SE oriented and westward lowered by normal faults, but higher up than the two most depressed coastal plains of Garigliano and Volturno rivers, ignimbrite flows overlapped to rocky units of the *horst* and emplaced in the current outcropping zone. During this phase, sedimentation environment was probably fluvial–marshy and flat. In addition, the shoreline was located about 10 km further off the current one (westward), and likely coinciding with present-day −60 m depth (Waelbroeck et al., 2002).

Please cite this article in press as: Pennetta, M., et al., Geomorphological features of the archaeological marine area of Sinuessa in Campania, southern Italy, Quaternary International (2016), http://dx.doi.org/10.1016/j.quaint.2016.04.019