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GEOMORPHOLOGICAL AND ARCHAEOLOGICAL EVIDENCE OF ROMAN TIMES SHORELINE IN THE LA SPEZIA GULF

ABSTRACT: CHELLI A., FEDERICI P.R. & PAPPALARDO M., *Geomorphological and archaeological evidence of Roman times shoreline in the La Spezia Gulf*. (IT ISSN 1724-4757, 2005).

Two sites in the western promontory of La Spezia Gulf are illustrated in which the identification of a shoreline slightly lower than present-day is possible. They are the archaeological site of Varignano Cove, a rural settlement of Roman Times where drainage channels in connection with a dock were identified and a cave in Palmaria Island (Riparo del Pozzale), in which a beach deposit was found in a pit 60 cm below present-day sea level. For both sites chronological attribution is discussed but we particularly focus, for each type of marker, on the sea-level indication and on the error associated to it. Available data point to a position of the 2,100 B.P. shoreline not higher than 41.5 cm below present-day sea level. This is consistent with a moderate uplift rate, testifying the general tectonic stability of the area in the upper part of the Holocene. The most recent tectonic behaviour of the area is comparable with what is known to be the crustal displacement trend in the area in the past 125,000 years.

KEY WORDS: Sea-level, Roman Times, Gulf of La Spezia (Italy).

RIASSUNTO: CHELLI A., FEDERICI P.R. & PAPPALARDO M., *Evidenze geomorfologiche ed archeologiche di una linea di riva di età romana nel Golfo di La Spezia*. (IT ISSN 1724-4757, 2005).

Sono illustrati due siti nel Golfo di La Spezia nei quali è possibile identificare una linea di riva di età romana. Si tratta del sito archeologico del Varignano, un insediamento rurale di età romana nel quale sono stati identificati dei canali di drenaggio in corrispondenza di un molo ed una grotta nell'Isola Palmaria (Riparo del Pozzale), nella quale è stato rinvenuto in sondaggio un deposito di spiaggia 60 cm al di sotto del livello del mare attuale. Per entrambi i siti si discute l'attribuzione cronologica ma principalmente si rileva la quota del livello del mare testimoniata da cia-

scun indicatore e si puntualizza il margine di errore ad essa connesso. I dati analizzati forniscono una quota del livello del mare di 2.100 anni fa non superiore a 41,5 cm al di sotto del livello marino attuale. La quota desunta della linea di riva è compatibile con l'esistenza di un moderato sollevamento tettonico, ad indicare condizioni di sostanziale stabilità nell'Olocene Superiore. Questo più recente comportamento tettonico è compatibile con il tasso di sollevamento degli ultimi 125.000 anni noto nell'area.

TERMINI CHIAVE: Livello del mare, Età Romana, Golfo della Spezia.

INTRODUCTION

Local sea-level curves are dependant on the combined effects of eustatic changes and isostatic and tectonic crustal displacements. For this reason, also for the most recent times of geological history, altitudinal differences in shoreline displacement are accounted for all over the world (Pirazzoli, 1991). In Italy (Lambeck & alii, 2004a) tectonic complexity is the cause of the frequent differences between sea-level curves built up by means of different types of indicators and those model predicted. Measuring with great accuracy shorelines displacements is therefore of the greatest importance for outlining models of tectonic behaviour and trends of uplift/subsidence rates.

Archaeological markers proved to be very useful for highlighting recent tectonic displacements, provided that they are correctly employed (Alessio & alii, 1994; Morhange & alii, 2001; Sivan & alii, 2001; Antonioli & alii, 2003; Faivre & Fouache, 2003; Lambeck & alii, 2004 a and b). Among archaeological markers those preferred are *piscinas*, whereas coastal wells bear information about the palaeo-watertable at the time of their use and this provides an indirect measurement of sea-level position. In employing archaeological sea-level indicators some cautions should be carefully observed: functional interpretation of the indicator should be perfectly clear and an error bar should be associated to the measure, taking into account instrumental errors as well as the tide oscillation range.

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Work supported by University of Parma local funds FIL2004 «Evoluzione geomorfologica tarso-quadernaria: casi di studio nelle Alpi Marittime e nell'Appennino settentrionale» (Head: Dott. S. Perego) and CNR-GNDCI funds 2001 line 14 (Head: Prof. P.R. Federici).

Authors are very grateful to Dott.ssa L. Gervasini (Soprintendenza per i Beni Archeologici della Liguria) and Prof. M. Bernini (Università di Parma) for the useful information and topic discussion.

The tectonic setting of La Spezia Gulf, dividing the Northern Tyrrhenian and the Ligurian Sea, is the key for the interpretation of its morphology (fig. 1). On the western promontory of La Spezia Gulf, known as promontory of Portovenere, and on the three islands of Palmaria, Tino and Tinetto, that are on its prosecution towards SSE, the formations of Tuscan Nappe outcrop. Mainly they are a sequence of limestones, dolomitic limestones, marls and sandstones from mesozoic to tertiary in age. The nappe forms a WSW-verging recumbent fold with its axis faintly dipping towards NNW; this fact accounts for the outcropping of the reverse limb of the fold in the promontory and the islands (Giammarino & Giglia, 1990).

The gulf itself is a depression, NW-SE stretching, bordered by two parallel promontories affected by normal faults parallel to the folds axes, dissecting the promontories into separate blocks. Such faults, that have been active at least since the end of Pliocene, have modelled the promontories on both sides in the form of staircases. The activity of these faults is not well defined through time and it is unclear whether they have been moving during the Holocene. Rock terraces between 10 and 15 m along the coast (Federici, 1987) were identified as marine and temporarily attributed to the Tyrrhenian. Unfortunately at present they are the only sea-level markers recognized in the area but as the original deposit is never preserved on them both genesis and age attribution are still uncertain. If they were Tyrrhenian markers, though, they would testify a relative tectonic stability in the area since MIS 5.5, or better an average very moderate uplift rate.

Although archaeological markers have already been employed in this area (see further on) no more than an indication of substantial tectonic stability is accounted for. Our paper is aimed at finding some precise constraints on the sea-level altitude of Roman Times in the area by means of new archaeological and geomorphological data.

ARCHAEOLOGICAL EVIDENCE OF SHORELINE

In the La Spezia Gulf and the neighbouring Lower Magra Valley archaeological sites of Roman Age are present. They testify the interest of the Romans for this territory both for its beauty, its strategic position and its richness in natural resources.

One archaeological site displaying great interest for its position, in order to reconstruct the sea-level of Roman Age, is the maritime *Villa* of the Varignano Cove, along the western coastline of the La Spezia Gulf (fig. 1). The archaeological surveys performed since 1967 (about this subject see Bertino, 1998; Gervasini & Landi, 2002 and references therein) highlight the *Villa* was a rural-residential settlement, completely developed already at the beginning of the 1st century B.C., where one of the main activities was the production of the olive-oil. In the Middle Ages the *Villa*'s harbour was silted up and in front of it a post-medieval farm was built; in the 1950s a wall was built for military purposes in the innermost part of the cove between the site and the sea. As a consequence at present the entire site is few hundred metres far from the sea. For this site Caputo & Pieri (1976) assigned the height of -386 mm to the sea-level at 50-40 B.C. but they didn't specify which was the marker they used, i.e. to which building or part of it they referred the datum. On the contrary, Pirazzoli (1976) reported, for the sea-level at 50-40 B.C., a height of -500 mm, inferring it from the position of the bottom of an aqueduct indicating the Roman sea-level. Both papers are in agreement with Schmiedt (1972), who reported the datum of Varignano Cove and correlated it with another Roman Times sea-level marker inferred from the Bocca di Magra Villa, on the western side of the lower Magra Valley.

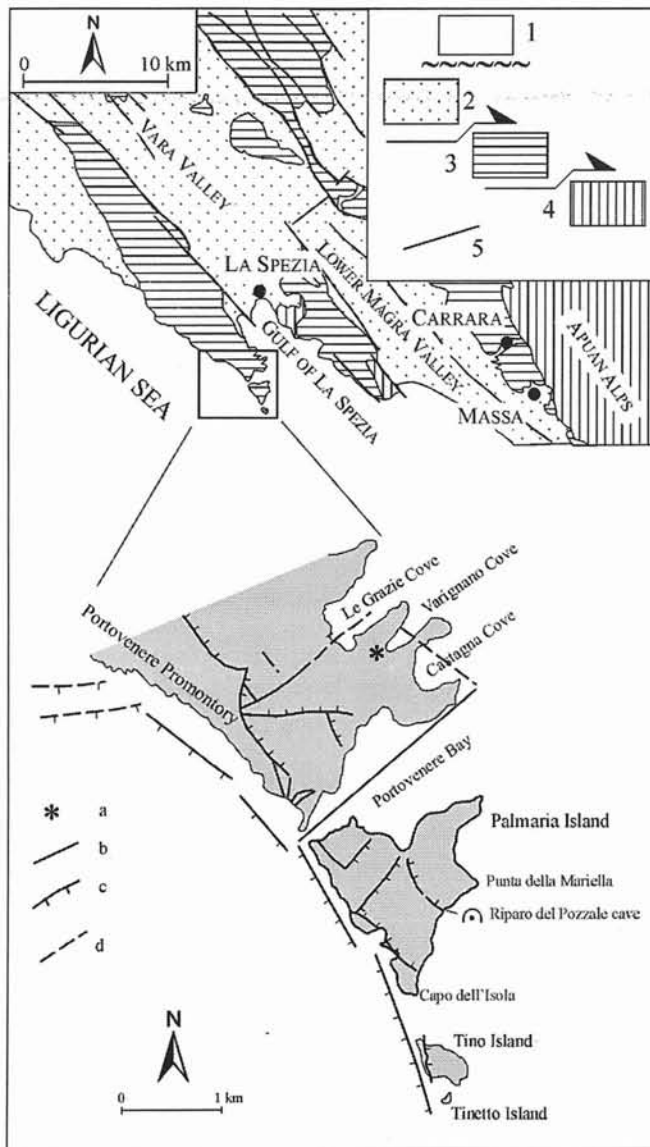


FIG. 1 - Location map of the study-sites and general tectonic features of the area. 1) Plio-Quaternary covers; 2) Ligurian Units; 3) Tuscan Nappe s.l.; 4) Metamorphic rocks; 5) Fault; a) Roman *villa*; b) Fault; c) Normal fault; d) Uncertain/hidden fault.

These estimates are not completely in agreement with one another.

For our purpose, we chose to consider the archaeological site of Varignano Cove as a reliable site, suitable to determine the sea-level of Roman Age in the western promontory of La Spezia and in the gulf islands. In fact it was not possible to identify surely either the remain that Pirazzoli (1976) named «aqueduct», or any of the features taken as a reference by the other Authors.

The archaeological literature and a recognition carried out in the Varignano site allowed us to get acquainted with the presence of a wharf connected to the *Villa* (fig. 2). It is located on the sea-ward side of the *Villa* and makes one of the sides of a wet dock located in the innermost part of the cove. The wharf, oriented about NW-SE, is 36 m long and 2.10 m wide and presents eight outlets of sewers on its NE side (fig. 3). At present, the use of a pump prevents the rise of the groundwater, avoiding the submersion of the *Villa*'s foundations (Bertino, 1998) and of the wharf.

In lack of other remains (i.e. *piscinas*) considered the best markers for the determination of Roman Times sea-level (Lambeck & *alii*, 2004 b), we chose to assume the



FIG. 2 - General view of the wharf of the Varignano villa.

outlet bases of the sewers as the best possible markers for our purposes; this assumption, in agreement with Pirazzoli (1976) is that sewer channels can have a good discharge only if the outlet base is higher than high-tide level.

We measured the altitude of the outlet bases of -21.5 cm below present-day sea-level. This was performed with trigonometric methods using as a reference the point of the National Elevation Network closest to the study site (at the Church of San Pietro in Portovenere) and employing a Sokkia Powerset series 100 instrument. This value represents maximum high tide sea-level at the beginning of the 1st century B.C. The error connected to this measure is due to the accuracy of the measurement of the selected archaeological feature, i.e. the instrumental error, which is +/-0.1 mm.

GEOMORPHOLOGICAL EVIDENCE OF SHORELINE

All the limestone formations outcropping in the mountain ridges surrounding the La Spezia Gulf (known as La Spezia Mounts) are affected by solution features both as surface (Federici, 1967) and underground landforms. Caves fillings and speleothems in La Spezia mounts are poorly known although they display a great interest and would deserve thorough investigation. In Palmaria Island there are about thirty caves, karstic in origin, but mostly remodelled by wave action (Cigna, 1967). In fact they are concentrated within the first 10 m a.s.l. but are present also at different altitudes.

In the island south-eastern coast a small cave opens at the cliff bottom protected by a narrow pocket beach (Spiaggia dei Gabbiani), 20 m wide in its central part. This cave, named by Cigna (1967) «Riparo del Pozzale» (fig. 1) is roughly hemicircular in shape, about 4 m long and twice wide and reaches its maximum height of 2.5 m by the entrance. The cave walls and roof are carved in the thick layers of limestone displaying an horizontal dip, and present calcite concretions. Tight to the cliff bottom (but only outside the cave) a coarse deposit 1.5 m high shelters almost completely the cave entrance. It is made of sharp edged limestone pebbles scattered within a silt matrix. This deposit displays a good long-shore continuity and presents many features in common with other deposits that can be found along the island coasts; they should be interpreted as accumulated by man's action, as the cliffs have been used as quarries at least since the early nineteenth century.

The cave bottom is located at present-day sea level; a trench was opened in it, the stratigraphy of which is reported in fig. 4. A succession of landward dipping layers (20° NW) was highlighted, some of which contain organic matter and traces of human presence; in the detail a top layer is made of sharp edged limestone clasts probably due to partial collapse of the cave roof; underneath the layers are fine grained (sandy silt in layer b and silty clay in c and d) with frequent organic matter. Layer e is

FIG. 3 - The sewer outlet on the Varignano warf used as a sea-level indicator: the base of the outlet could not be lower than the maximum high tide value.

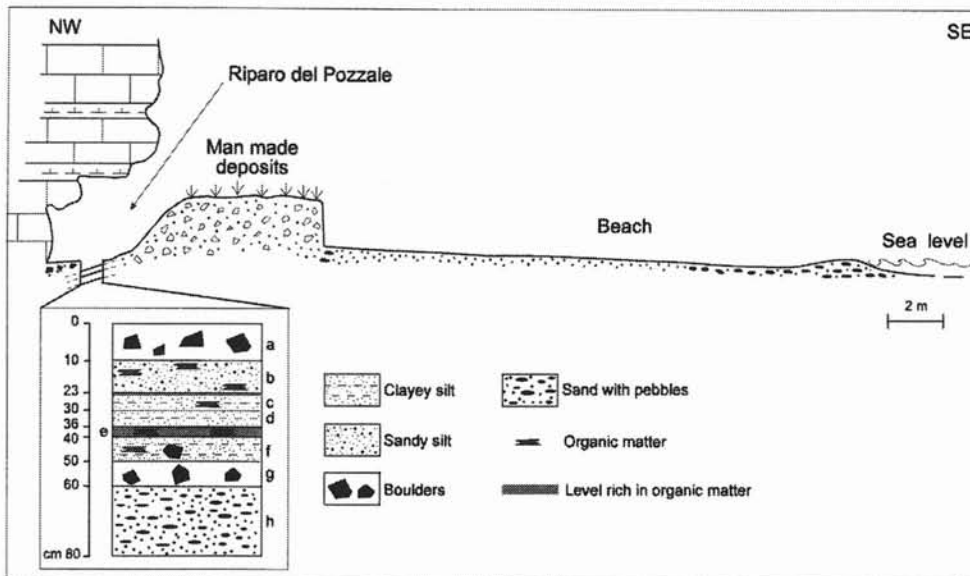


FIG. 4 - Section of the Riparo del Pozzale cave in Palmaria Island; in the detail the pit stratigraphy (drawn by E. Masini, Università di Parma).

very rich in organic matter (mainly charcoal) and contains discoidal pebbles with a diameter of 3-6 cm as well as few sharp edged ones. In layer f we find a mixture of silt, clay, coarse and sharp edged clasts and decomposed organics and finally a new, 10 cm thick layer, similar to a, lays directly on a sandy layer rich in discoidal pebbles similar in size to those found in layer e. Throughout the

cave fill man's artefacts (particularly big nails) and remnants of terrestrial animals (teeth) were found. They lack completely in the bottom layer, which was interpreted as a beach deposit. The bedrock depth in the pit beneath layer h is unknown.

A ^{14}C dating of charcoal present in layer e was performed and the result gave a radiocarbon age of 140 ± 120

BP yr ^{14}C . The actual carbon present in the sample was a very low percentage perhaps because the combustion process stopped at an early stage. The measure displays therefore a large sigma, which was the best possible result for that sample. This dating can support the interpretation that the sample is historical and dates very likely up to the half of the nineteenth century, as suggested the presence of modern age nails in the deposit, used probably for quarrying activity. Del Soldato & Pintus (1985) report that the modern exploitation of the La Spezia Gulf islands for quarrying purposes began in the nineteenth century and that in 1862 there was one quarry in Tino island and five in Palmaria (there have been up to fourteen quarries active simultaneously late in the nineteenth century).

The cave fill must have formed rapidly for accumulation of waste material by quarry workers that used the cave as a shelter.

Geomorphological evidence accounts for the following palaeogeographical evolution: the buried beach was forming when the sea-level was about 60 cm lower than present-day. The sand stopped accumulating inside the cave consequently to beach progradation. Enhanced shoreline advance in the area since at least the early Middle Ages is supported by literature data accounting for scree slope formation and landsliding due to a cold-damp climatic phase (Chelli & Tellini, 2001) and flooding (Fazzini & Maffei, 2000).

The beach that formed in this site was almost completely eroded in the early 1800s when big limestone quarries were established on Palmaria Island. Useful data on pre-quarrying morphology can be obtained analysing the paintings dating back to 1808-1811 drawn by Capt. Pierre Antoine Clerc, a topographer of Emperor Napoleon, presently preserved at the Historical Archive of La Spezia Municipal Library. Some of these paintings show in its untouched aspect the coast tract from Capo dell'Isola to Punta della Mariella (fig. 1). A comparison with present day morphology highlights that in the early nineteenth century the cliff (the edge of which reached the altitude of about 50 m a.s.l.) was plunging directly into the sea; the beach was lacking, apart from a small sandy pocket close to Punta della Mariella. Only the lower part of the cliff is preserved in present-day morphology (from the sea-level up to about 15 m above it): the upper part was quarried and at the cliff bottom the waste material was accumulated, that supplied the fines for modern beach formation and nourishing. In the early 1800s beach erosion was widespread along the northern Tyrrhenian and Ligurian seas. Literature data account for this erosional phase for the Magra and Arno Plain (Mazzanti & Pasquinucci, 1983), but also for the Entella Plain at least since 1810 (Cortemiglia, 1987). Later on the cliff quarrying began and the waste material was accumulated at the cliff bottom, forming the deposit sheltering the cave entrance. This manmade deposit supplied longshore drift with the material necessary to form the beach in front of the Riparo del Pozzale cave, which is nowadays the best preserved of Palmaria's beaches, but which is again subject to wave erosion.

DATA ANALYSIS

Among the available markers the ones that permit identification of the shoreline with the most limited margin of error should be chosen. This is most important when the shorelines are very recent, and the shift in sea-level is consequently very small, so that it might be exceeded by the error. For example beach (foreshore) deposits can be considered poor quality markers, as the uncertainty associated to them is very high, about $+1/-5$ m, according to Nisi & alii (2003). Anyway morphostratigraphical and spatial correlations can greatly improve the quality. In this case in fact we intend to date indirectly the Palmaria beach deposit by comparison with the neighbouring archaeological site. The archaeological indicator we chose, although not included among those most commonly employed in the literature, supplies in our opinion a reliable value of the maximum altitude reachable throughout the year by the high tide.

The Roman Times shoreline elevation value obtained for the Varignano Cove was compared to that of the eustatic sea-level at the same time according to one of the available eustatic curves, i.e. the one by Morhange & alii (2001), based on archaeological and biological evidence from the ancient harbour of Marseille, an area traditionally considered stable for the last climatic cycle and not too far from the study site. We decided instead to neglect the curve by Alessio & alii (1994) because, although it is still considered a reliable reference for the Holocene sea-level in Italy (it was used by Antonioli & alii, 2003), it was built up for the Roman age using, among other data, the literature data by Schmiedt we intend to improve.

The altitude of the outlet bases we measured (-21.5 cm, h_M) should be considered the level that sea never exceeded (even when the tide was at its maximum) in the Varignano Cove at about 2,100 B.P. If we neglect the instrumental error connected to the measure we performed (± 0.1 mm) and consider the maximum tide positive excursion in the La Spezia Gulf of 20 cm (dT) (data after the Istituto Idrografico della Marina), the past value of the mean sea-level is $h_M - dT = (-21.5 - 20)$ cm = -41.5 cm. The uncertainty of ± 20 cm is in agreement with the correction for tidal effects which, according to Lambeck & alii (2004), should be performed in the Tyrrhenian Sea using as a marker submerged archaeological remains.

The obtained value fits in the range of $-40/-80$ cm considered by Morhange & alii (2001) representative of the eustatic sea-level of 2,000 B.P. in the Golfe du Lion.

At the light of this evidence we can say that the beach deposit found in the Riparo del Pozzale cave on the southeastern coast of Palmaria Island can be related to the Roman Times sea level. The buried beach top is 60 cm lower than present-day sea level, so considering the error bar accepted for foreshore deposits ($+1/-5$ m) it is consistent with a deposition around 2,000 B.P.

FINAL REMARKS

The main result of this work is constraining the elevation of the Roman Times shoreline in the La Spezia West-

ern Promontory within a very narrow altitudinal range and to highlight evidence of it also in one of the Gulf Islands (Palmaria), where up to present-day no marker with this significance was ever found.

Furthermore, some remarks on recent tectonic movements in the area are possible according to the exposed data. From a tectonic point of view we can draw the conclusion that no relevant tectonic uplift has occurred in the western La Spezia promontory since Roman Times. In fact the obtained shoreline value is consistent with the eustatic altitude obtained by Morhange & *alii* (2001) in the Golfe du Lion. If we consider that our value is located at the top of the altitudinal range accepted for the Southern French coast, moderate uplift characterizing the area in the Late Holocene can be admitted. This uplift value (about 10 cm/ky, if we consider -60 cm the eustatic + hydro-isostatic sea-level) should be comparable to the average rate (16 cm/ky) for the past 125,000 years calculated in another site in Eastern Liguria by Federici & Pappalardo (2004). This fact is in agreement with the evidence that average uplift rates for the past 125,000 years are, in most of the Italian coasts (Lambeck & *alii*, 2004) but also somewhere else in the Mediterranean (see e.g. Sivan & *alii*, 2001), comparable to those of the Holocene.

This uplift is consistent with the tectonic history of the area. In fact the Gulf of La Spezia is a graben determined by normal fault systems trending NW-SE crossed by about NE-SW-trending ones showing both normal and strike slip motion and by ENE-striking faults, with generally only normal motion (Carter, 1991). In correspondence of these faults movements responsible for extensional tectonic regime occurred since the Upper Pliocene, during which began the deposition of the continental sequences in the Vara Valley (Bertoldi & Castello, 1990), of which the Gulf of La Spezia is the prosecution towards SSE. The extensional regime was not continuous and constant through time, but it was interrupted by phases of uplift affecting the Vara Valley-Magra Valley graben system (Bernini & Papani, 2002). On the whole it is likely that the extensional movements could have played the role to redistribute the uplift in a differential way on the entire area. Moreover, the presence of the fault systems may have determined differential movements along the Portovenere Promontory and between it and the islands.

For other sites along the coast of Eastern Liguria and Northern Tuscany different Authors reported the presence of remains that allow a reconstruction of ancient sea levels and shorelines (Caputo & Pieri, 1976; Pirazzoli, 1976; Schmiedt, 1972; Raggi & Sansoni, 1992-3). In the Luni site, the ancient Roman town in the Lower Magra Valley, the presence of a sewer (behind the *cardus maximus*) and, in particular, the height of the bottom of its outlet were considered. Caputo & Pieri (1976) referred their measures to the 1884 mean sea level. They reported a height of -886 mm for the sea-level of the 177-157 B.C. Pirazzoli (1976) established a difference between the present mean sea-level and the 177 B.C. one of 600 mm. According to the above mentioned literature data tectonic

stability seems to have affected the area of Luni, immediately SE of the La Spezia Gulf. In the Entella Plain, 50 km NW of the study area, evidence of a Iron Age shoreline in the Chiavari necropolis site (dated to the VIII century) -2 m below present-day sea-level is reported by Fanucci (1978). In this case enhanced subsidence of the plain should be admitted, as -2 m is a value far below the eustatic sea-level for that time. Further work should therefore focus on correct identification, measurement, dating and correlation of archaeological and geomorphological Holocene shorelines markers in the La Spezia Gulf and neighbouring areas.

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