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SERGIO GINESU (*) & ANDRÈ OZER (**)

RECENT EROSION ON THE NORTHERN COAST OF SARDINIA: A RADIOMETRIC DATUM ON THE FIUME SANTO COAST

ABSTRACT: GINESU S. & OZER A., *Recent erosion on the northern coast of Sardinia: a radiometric datum for the Fiume Santo coast.* (IT ISSN 0391-9838, 2002).

Thanks to sampling of vegetable remains offshore from the Fiume Santo beach, it has been possible to define the recent withdrawal of the coastline during the Holocene with greater precision. The age of 4420 ± 70 years BP of a fossil tree allowed an shoreline retreat estimate of 250 m, consistent with a retreat rate of about 6 cm/y. Moreover the bottom morphology facing the beach confirms the model of coastal evolution in the area and affords a close correlation with the data on the movement of sandy masses known in the literature.

KEY WORDS: Shoreline erosion, ^{14}C, Sardinia.

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Il campionamento di resti vegetali al largo della spiaggia di Fiume Santo ha permesso di definire con maggior precisione lo stadio di arretramento recente della linea di costa nel corso dell'Olocene. L'età di 4420 ± 70 anni dal Presente di un tronco d'albero fossile in posizione di crescita ha permesso di stimare l'arretramento della linea di riva in circa 250 m, con un ritmo di arretramento di circa 6 cm/a. Inoltre le morfologie del fondale prospiciente la suddetta spiaggia confermano il modello di evoluzione costiera ancora presente nell'area e permettono una stretta correlazione con i dati di spostamento di masse sabbiose già noti in letteratura.

TERMINI CHIAVE: Variazione della linea di riva, ^{14}C, Sardegna.

INTRODUCTION

The coastal erosion process is an important problem that arouses a lot of interest. In particular when it occurs along coastal tracts exposed to high anthropic frequentation. Though tourist-housing settlements along the coast are rare in Sardinia and cities on the sea are few and isolated, local collapses and natural disasters have occurred in relation to the aggravation of the shoreline withdrawal process. The coasts of the whole of Sardinia are thus periodically and constantly kept under observation to obtain the greatest possible amount of data and information to monitor the degradation of beaches most at risk on the island.

Within ministry projects (M.P.I. - C.N.R., MURST, and COFIN) the research unit of the University of Sassari has checked the state of health of the coasts of north Sardinia and has concentrated its attention on areas at greatest risk. The tract of coast between the mouth of the Fiume Santo river and the communication outlet of the Stagno di Pilo lagoon has been investigated in particular depth in its geological and stratigraphic layout (Ozer, 1977; Ginesu & *alii*, 1992; Cordy & Ginesu, 1993) since as it hosts the largest industrial pole in the north of Sardinia, it has supplied an enormous amount of information and data particularly useful in studies of the physical environment.

Recently, from studies aimed at reconstructing the morphology of the submerged beach offshore from the Pilo beach, just west of the Fiume Santo power station (block I and II), that were carried out in an attempt to define the confines of the old lagoon, it was possible to reconstruct the progressive withdrawal of the beach in prehistoric times and recover sediments of organic plant remains, which based on a precise radiometric dating,

(*) *Istituto di Scienze Geologico Mineralogiche. Università di Sassari. Italia.*

(**) *Département de Géographie Physique, Géomorphologie et Teledetection. Université de Liège. Belgique.*

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have partly led to reconsider the previous temporal reconstruction of the found submerged morphologies.

MORPHO-LITHOLOGICAL FRAMING

The land between the Stagno di Pilo lagoon and the mouth of the Fiume Santo river is made up of a basement of prevalently calcareous rocks belonging to the Jurassic and Trias formations that outcrops extensively in the immediate hinterland (fig. 1). Nevertheless, these formations do not outcrop along the coast, since they have been lowered by lines of fault parallel to it; therefore the strip nearest the coast is made up of different kinds of detritic rocks amply described in previous works (Ozer, 1976, Ginesu & *alii*, 1992; Ginesu, 1995).

From an administrative point of view, the area is part of the municipal territory of Sassari, even though it is in the immediate periphery of the city of Porto Torres and in continuation of the petrochemical industrial pole that is developing on the coast between Fiume Santo and the port area of Porto Torres.

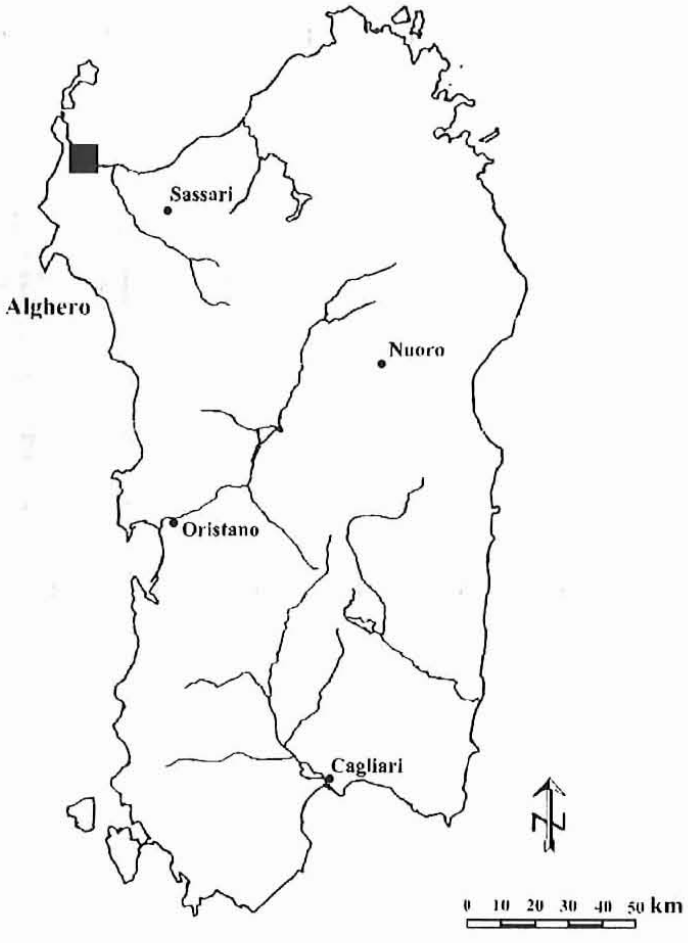

FIG. 1 - Localization of the study area.

The coastal strip involved in the study is therefore submitted to intense anthropic activity that has deeply changed the natural layout of this land, favouring changes in both short and long term, but supplying a large amount of data on a few areas.

Recently, a long pipeline has been built parallel to the coastline from the power station to the jetty where ships moor, above the calcareous and volcanic rocky basement; this has provided an interesting field of investigation for the geomorphological reconstruction of the area, which will be described in a subsequent paper.

In the tract considered in this work, a small watercourse, the Fiume Santo river, flows into the sea and gives its name to the entire area, while a smaller watercourse supplies the Pilo lagoon (fig. 2) whose origin is related to more recent fluctuations of the sea level. The lagoon is based on alluvial detritic rocks that outcrop in the area and have filled the small graben of Fiume Santo - Scala Erre forming an old delta fan that develops as far as the present sea level (Ginesu & Sias, 1992). These detritic nappes, which are rather thick at certain places (over 100 m in the Scala Erre area) have been attributed to the Upper Miocene (Cordy & Ginesu, 1993).

Morphologically the territory of northern Nurra is dominated by a mature landscape (Federici & *alii*, 1987; Ginesu & Sias, 1998) with clear forms related to long modelling processes that led the ranges to take on residual shapes joined together on pediment slopes, which extend northwards with slopes not greater than 6° generally supported on Mesozoic calcareous substrates covered by residual «Terra Rossa» soils.

The same detritic deposits of the end of the Miocene (Cordy & Ginesu, 1993) are concordant with the levelling surface on the limestones and further document the presence of a small retarded *graben* in the tertiary evolution of the northern fossa (Cherchi & Montadert, 84; Federici & Ginesu, 95). The set of morphological and lithological characters is visible in the outcrops along the coastal profile of this tract where a paleocliff is present with at its foot sediments and deposits related to the different fluctuations of the marine level during the Pleistocene.

GEOMORPHOLOGY OF THE EMERGED AND SUBMERGED AREAS

The situation of the entire Asinara Gulf is considered at an environmental risk on account of the large anthropic impact of the factories and the urbanisation on the territory; precisely for this strong anthropic impact on the territory, the problem of sea erosion is particularly evident especially on the nearby coast of Platamona-Marritza, which has been described and documented in other studies (Federici & Ginesu, 1987; Ginesu, 1992). The lay-

FIG. 2 - The aerial view with the localization of the sampling place. The southern slopes are cutted by the Thyrrenian cliff.

out of the studied coastal tract has been the subject of detailed studies that clearly prove the frequency and dynamics of the fluctuations of the coastline in recent times, which are testified on land both by a number of morphologies, such as the well preserved Tyrrhenian cliff along the western terraced margin of the Fiume Santo plain, and by beachrock and dune deposits along the perimeter of the Stagno di Pilo lagoon and at a depth of about 2 metres offshore.

Abundant beach deposits are found along the inner edge of the submerged seabank of the Stagno di Pilo lagoon, up to 2 metres above the present sea level, associated with sediments of lacustrine origin rich in the classical lagoonal fauna association (Ozer, 1976) in witness of the persistence of similar conditions since the last interglacial phases.

More recently the progressive advancement of the coastline is documented historically by the ruins of a Roman «villa» near the mouth of the Fiume Santo river, partly submerged but not yet studied by archaeologists. This testimony confirms a datum known in other parts of Sardinia where contemporary monuments are found in the same partially or totally submerged conditions.

Within the Baja di Porto Conte on the western coast of Nurra, a recent work (Federici & *alii*, 1999) has reconstructed the coastline with precision thanks also to the presence of an important, well studied imperial «villa».

In the Fiume Santo area, investigations carried out on the geomorphological reconstruction and dynamics of bottom changes in 15 months, have led to an assessment of the movement of bottom sands in the area facing the ENEL power stations in about 641,000 m^3 for a balanced mean in 28,616 m^3/km^2 (Ginesu & *alii*, 1994).

Therefore, from the reconstruction of bottom changes and from the speed of movement of the sandy masses, it has been possible to identify underwater depressed morphologies attributed to the presence of paleolagoons in front of the submerged sandbank of the Stagno di Pilo lagoon and the mouth of the Fiume Santo river.

These morphologies have been traced back to the withdrawing coastline which forced the lagoon to the present condition but without obtaining a precise chronological reference index, which is possible today thanks to precise radiometric dating.

RADIOMETRIC DATA

During prospecting campaigns in spring 1999, a few immersions were carried out just offshore from the submerged sandbank of the Stagno di Pilo lagoon in the submerged area below the –5 isobath in order to check the conservation state of the *Posidonia oceanica* vegetation in the sandy deposits that make up a feeding reservoir for the small beach that is forming along the pier of the Fiume Santo power stations 1 and 2.

Recent storms had pointed out the substrate supporting the sand locally, and which can also be seen from aerial photos of the areas near the Stagno di Pilo beach (fig. 2). On this occasion a few surveys were carried out on the deposits that made up the basis of these sediments and which, given the fine matrix, immediately proved to be ancient palustrine deposits, which on account of the presence of palustrine fauna and clayey sediments similar to those found at the basis of the present lagoon were easily attributed to an old geographic condition of the Stagno di Pilo.

In particular, a fragment of a fossil trunk that emerged from the sediment was collected and immediately sent by the laboratory to Beta Analytic Inc. in Miami, Florida for radiocarbon dating. The obtained data changed the formulated hypotheses that considered these sediments attributable to the rising level of the sea before the Holocene with a possible age of about 20/30,000 years before the present. The laboratory results gave an age of 4420 ±70 before the present pointing out a withdrawal of the coastline of a few hundred metres (about 250) over a very short period with a ratio of about 6 cm/year.

CONCLUSIONS

In the light of the new results, we can make the following remarks, which offer new knowledge on the coastal dynamics of the western sector of the Gulf of Asinara. It should be mentioned first of all that the calculation of 6 cm/year is a simple equation derived reading the data relating to the past 4000 years without considering periodical fluctuations, and in particular without giving a precise assessment of the impact of harbour works along the coast between Fiume Santo and the city of Porto Torres (including the ancient port of the city).

In the second half of the past century, works were carried out for many decades in this tract of coast, causing a significant change in the coastline and the total disappearance of coastal morphologies such as the Gennano Lagoon.

It can be hypothesised therefore that coast withdrawal was more marked in the past centuries with a greater peak in the past decades; recent evidence has emerged also in the neighbourhood of the studied area, where archaeological and paleontological remains show similar withdrawal values that can be dated to historical periods (Ginesu & Wilkens, 2000), thus reproposing particularly high estimates of the process of degradation and erosion of a few tracts of the Sardinian coast, as emerged in the general literature on the subject.

A survey of the western coast of the Gulf of Asinara could confirm that the studied area is submitted to a high rate of erosion and transportation of sedimentary material that would favour the fast transfer of sands westwards.

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