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"HEADLAND OR STACK? PALEOGEOGRAPHIC RECONSTRUCTION OF THE COAST AT THE FARAGLIONI MIDDLE BRONZE AGE VILLAGE (USTICA ISLAND, ITALY)"

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ABSTRACT

The Faraglioni Village at volcanic island of Ustica (Palermo, Sicily) is one of the best preserved coastal Middle Bronze Age site of the Mediterranean area. It was built on a marine terrace overlooking the sea. Although the southern border of the Village is well defined, many doubts concern its past extent toward the sea. Around 3250-3200 BP the inhabitants suddenly abandoned the site, leaving all their belongings. This sudden flight could be related to a natural disaster that induced the population to find a safer place, or to a hostile invasion from the sea. The coast is formed by 20 m-high sea cliffs, which are often subject to collapses. A small platform develops at the cliff toe and it is locally covered by a beach with pebbles, cobbles and rounded blocks. Off-shore, in front of the archaeological village, a stack, called Colombaio, occurs. It is 17 m x 11 m wide at the top, roughly at the same elevation above the sea level of the terrace on which is located the Faraglioni Village, and it lies about 60 m from the sea cliffs. The latter are cut in columnar basalts, roughly 1 meter in size. A sea cave, 14 m long, 6 m large and 9 m high was discovered inside the stack during the field surveys. There are many submerged or slightly emerged rocks in the canal between the stack and the mainland. Since archaeological remains have been found on the top of the stack, archaeologists suppose that there was a connection with the mainland. Literature suggested that most probably a natural bridge connected the stack and the coast; and that it collapsed as a result of a natural catastrophic event, such as an earthquake. Bathymetric data compared to the sea level change models suggest that the area of the village was largest than nowadays, but the retreat rate is unknown, so it is impossible to estimate the Bronze Age extent of the village and assert that it was certainly connected with the stack. The separation of the stack from the coast could have happened long time before the Bronze Age. Probably, only the so-called Nerone stack was connected during the Bronze Age. However, it is not necessary to hypothesize the occurrence of a natural "bridge" or a human-made connection with the stack from the mainland at the same elevation of the village, because during the Middle Bronze Age, about 3400-3200 BP, the sea level was 3 meter lower than today and the path between the mainland and the stack was about 1 m above the past sea level. The stack was isolated from the village only during severe storms.

1. INTRODUCTION

Coastal archaeological sites in the Mediterranean basin often allow to infer the relative sea level changes occurred in the Late Holocene [e.g. Antonioli et al., 2007; Anzidei et al., 2014] or to reconstruct the paleogeography of the ancient landscape [e.g. Mourtzas and Kolaiti, 2013; Benjamin et al., 2017]. In some cases, archaeological remains along the coasts provide unequivocal elements to relate their functional elevation to past sea levels [Auriemma and Solinas, 2009], because of their architecture and proximity to the sea. In other cases, the archaeological structures are not related to functional elements, but the relations with past sea levels can be deducted from a comparison with additional data, such as the proximity with scenic landforms. Archaeological sites may have been built near coastal landforms whose evolution can be totally or partly reconstructed [Sunamura, 1992]. In this case, it is possible to infer about the evolution of the archeological remains starting from the evolution of the landscape. It is the case of coastal sites where marine processes act on artefacts following the evolution of the landscape in which the site is located. In case of proximity with coastal landforms, such as stacks, sea arches, sea caves, etc, interlinked informations can be collected. Many attempts were made around the world to reconstruct their evolution, such as at La Jolla in California [Shepard and Kuhn, 1983]. The reconstruction of the evolution of the coastal scenery can be very difficult, or impossible, just because of sudden and unpredictable changes, followed by the complete removal of the original materials. The evolution of stacks and sea arches can be very dramatic, leading to their complete disappearance following rapid catastrophic events. In March 2017 the sea arch called Azur Window, in Gozo, Malta, suddenly collapsed during a storm, also erasing the stack, which is commonly thought as the result of arch collapse [Sunamura 1992]. On the contrary, the presence of a well-preserved archaeological site close to the stack provide data to discuss the evolution of the coastline with more certain constrains.

The Faraglioni Village at Ustica island is one of the best preserved coastal Middle Bronze Age site of the Mediterranean area [Counts and Tuck, 2009], but many doubts concern its seaward border, because of the local geomorphological setting. In this paper, we aim at discussing the changes of the coastline and the consequent modifications of the coastal viability of the Faraglioni Middle Bronze Age Village by means of new bathymetric measures, geomorphological surveys and comparison with late Holocene sea level change curves.

2. STUDY AREA

2.1 GEOLOGICAL FRAMEWORK

Ustica Island (Figure 1) is located about 60 km off the North-West coast of Sicily and 150 km West of the Aeolian arc; it represents the emerging top (about 8.5 km2 large) of a vast submarine volcanic complex. It is an extinct volcano, without any activity in the last 130 ka [Romano and Sturiale, 1971; de Vita et al., 1998], mainly composed of volcanic rocks, and subordinately of marine deposits of the Middle-Upper Pleistocene sea level highstands. They generated five orders of marine terraces [de Vita and Orsi, 1994]. The Ustica volcanic rocks have a Na-alkaline affinity, ranging in composition from alkali-basalts to alkali-trachyte, with a compositional gap in the field of benmoreite, 55-60 wt % SiO2 [de Vita, 1993; Peccerillo, 2005].

Ustica's origin is related to crustal transtensional faults, generated during the deformational events that followed the opening of the Tyrrhenian Basin in the Late Miocene, in the context of the complex interaction between the African and Eurasian plates [de Vita et al., 1995].

The island of Ustica is located above a 30 km thick continental crust [Agate et al., 1993; Sulli, 2000]. Seismological data suggest that the north Sicily offshore is affected by compressive stress [Agate et al., 2000; Pepe et al., 2005]. The study area is, in fact, part of an active E-W oriented contractional belt, which also includes the western sector of the Aeolian archipelago [Bousquet and Lanzafame, 1995]. This belt shows a geodetic shortening of 1-1.5 mm/yr [Devoti et al., 2011; Palano et al., 2012]. Its central side is affected by frequent, moderate-sized crustal thrust earthquakes [ML<6, 15–20 km of depth, Pondrelli et al., 2006; Billi et al., 2007; Giunta et al., 2009], with P axes constantly trending NW-SE.

The Ustica volcanic activity began in the Early-Middle Pleistocene [Barberi and Innocenti, 1980], in a submarine environment, along a NE-SW trending fault system, where several eruptive centres are located. The northernmost part is characterized by spectacular outcrops of columnar joints, from the Punta dello Spalmatore area to the study area.

de Vita and Orsi [1994] identified a suite of five marine terraces ranging in altitude from 5 m a.s.l. up to over 100 m a.s.l. Some MIS5.5 (Tyrrhenian) terraces were found at about 30 m a.s.l. in the eastern side of the island and at up to about 50 m on the western side [de Vita and Orsi, 1994; de Vita et al., 1998; Buccheri et al., 2014; de Vita and Foresta Martin, 2017].

The Middle Bronze Age Village is located on the top of a terrace overlooking the sea, on the northern side of the island. Here, the coast consists of a 20 m-high cliff characterized by a succession of lava flows in form of massive columnar joints. These litostratigraphic units were generated by a subaereal activity that took place in the Middle Pleistocene, about 350 ka ago [de Vita, 1993]. The cliffs are the result of a fault oriented NW-SE that cut the coastal profile in a straight line and

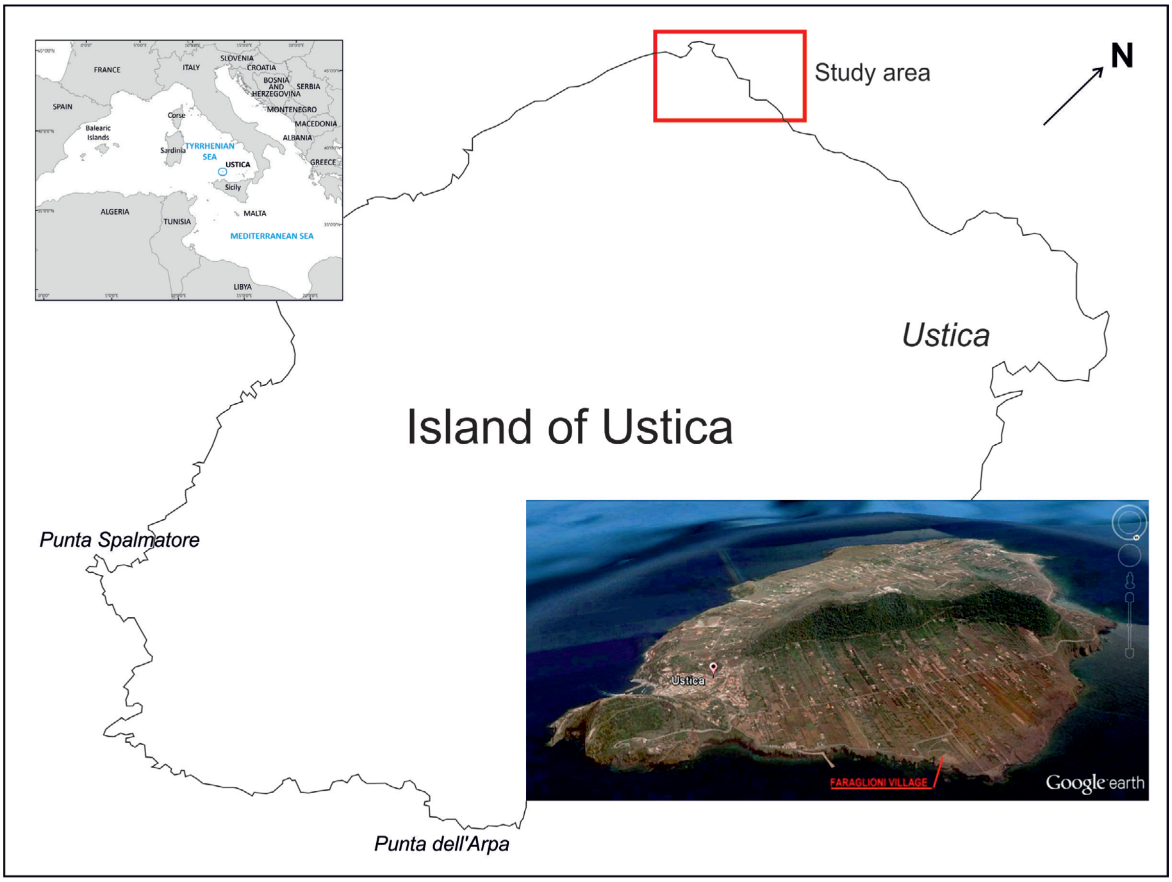

FIGURE 1. Sketch of the study area. The Faraglioni village and its surroundings are situated at the northernmost sector of the island of Ustica.

made it strongly unstable, subject to frequent landslides (stoppling and rock-falls) and collapses.

Ustica is prone to frequent earthquakes, usually characterized by small magnitude and shallow hypocenters [Chiarabba et al., 2005; Billi et al., 2006]. One of the most important seismic sequences localized in the area occurred in 1906, causing the evacuation of the island [Martinelli, 1910]. According to the Parametric catalog of Italian Earthquakes [Rovida et al., 2016], the energy released by the main shock of the sequence corresponds to $Mw=4.63 \pm 0.46$. Despite the low intensity of this earthquake, extensive damage in the eastern part of the island was reported, without, however, detecting any dislocations or faults scarps [Foresta Martin et al., 2011]. During the next two decades, a further three seismic sequences struck Ustica, with another earthquake of equivalent magnitude ($=4.63 \pm 0.46$) in 1924 [Rovida et al., 2016].

2.2. THE FARAGLIONI VILLAGE

The island of Ustica was populated since the Neolithic Age, in the 6th millennium BC, although not continuously [Mannino, 1998; Spatafora and Mannino, 2008]. In prehistoric times the apex of human presence at Ustica was achieved during the Middle Bronze Age, between 1400-1200 yrs BC, when the island was intensely and permanently inhabited. In this period, there exist many traces of small Middle Bronze Age dwellings: at Punta dell'Omo Morto on the eastern side of Falconiera hill; at Case Vecchie, upstream of the Ustica town on the south-east; at Spalmatore and at Piano dei Cardoni districts, respectively on the western and southern sides of the island. But the most important settlement of the Middle Bronze Age was located on a large rock terrace overlooking the sea at Piano di Tramontana district, on the northern side of the island. This conspicuous archaeological settlement is called "Villaggio dei Faraglioni", after a sea stack ["faraglione" in Italian, Spatafora and Mannino, 2008].

Several different archaeological excavations, carried out since the Seventies by Mannino [1970, 1979, 1982], Ross Holloway & Lukesh [1995, 2001] and Spatafora [2005] highlighted a settlement that has been defined one of the best-preserved Middle Bronze Age town of the Mediterranean region [Counts and Tuck, 2009] (Figure 2).

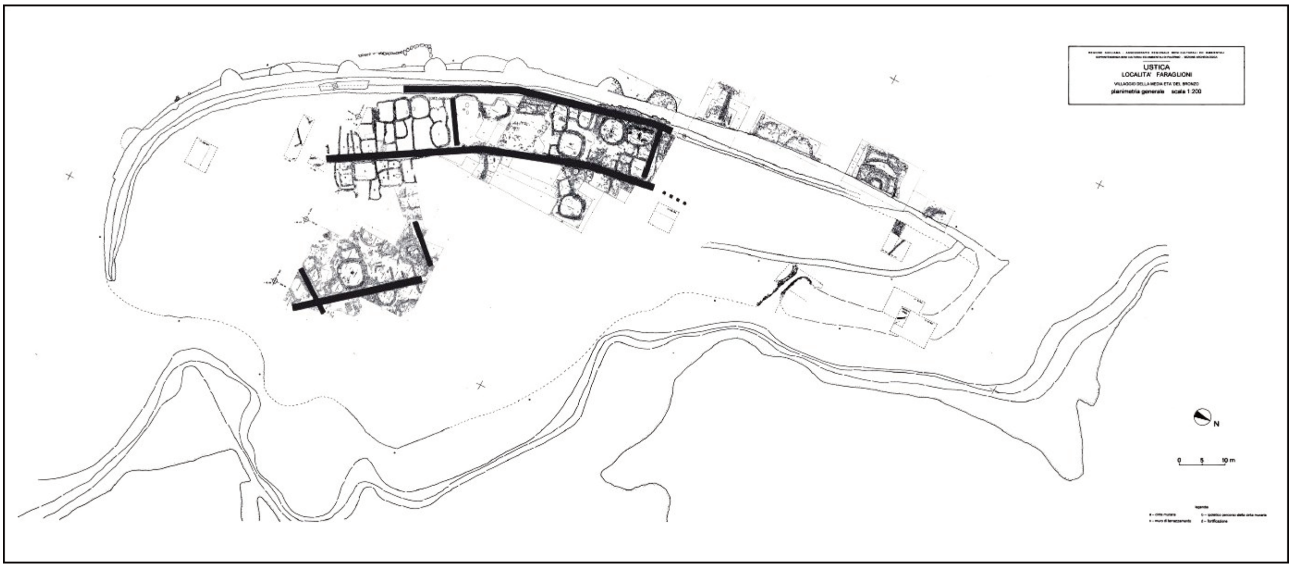

FIGURE 2. Sketch of the Middle Bronze Age Faraglioni Village [from Spatafora, 2016].

Southward the village is defended by a massive fortification wall which delimits an area of about 7000 square meters; northward it is naturally protected by the sea and the sea cliffs. Inside the wall dozens of huts and courtyards, organized along main longitudinal walk roads, have been unearthed. Hundreds of people lived in the Faraglioni Village, which was part of the Tyrrhenian commercial routes that connected the western Sicily with the Aeolian Islands and with the eastern Sicily, where cultural facies of Milazzese and Thapsos were spreaded [Spatafora and Mannino, 2008].

The distribution of huts, courtyard and streets suggests the existence of an urbanistic plan similar to that found in the most famous and coeval village of Thapsos, in the Magnisi peninsula, near Syracuse, Eastern Sicily. The furnishing unearthed inside the huts was rich and well-preserved. Some vases recalls the style of coeval ceramics found in the Milazzese Village of Panarea, in the Eolian Islands; some other vases are in typical Thapsos Style, consisting of deep truncated cone bowls on high trumpet feet, probably used to consume meals sitting on the ground. The typology of furniture and the organization of living testify that a community devoted to fishing, agriculture and sheep farming inhabited the Village [Ross Holloway and Lukesh, 1995, 2001; Spatafora and Mannino, 2008].

Mannino [1982] reported the occurrence of huts and ceramics on the top of the Faraglione, and it could be connected to the mainland, maybe as part of the main settlement [Spatafora and Mannino, 2008].

Around 1250-1200 BC, the inhabitants suddenly left, abandoning all the belongings in their homes. Archaeological excavations show a plenty of furnishing still intact in their functional position, as it happens when people escapes from their homes, without ever going back to recover their assets. For this sudden flight, two hypotheses were advanced: a hostile invasion from the sea, or a natural disaster that induced the population to find a safer place. After this dramatic event, Ustica remained uninhabited for centuries, until the Hellenistic-Roman period, when we find new traces of an intense human presence on the island [Spatafora and Mannino, 2008]. The chronology is consistent with the end of the Late Minoan IIIB period, ca. 1250-1200 BC, which largely coincided with the end of the Minoan society, as defined and documented by potential earthquake archaeological effects at Late Minoan sites [Jusseret and Sintubin, 2012; Mourtzas and Kolaiti, 2016, Mourtzas and Kolaiti 2017]. At that time, a number of Minoan coastal sites, such as Kommos, Mallia, Sissi, Mochlos, Kato Zakros and Palaikastro, were destroyed and abandoned forever. At Kato Zakros, Nur and Cline [2000], Nur and Burgess [2008], Mourtzas and Kolaiti [2016], Mourtzas and Kolaiti [2017] related the relative sea level changes to the impact of possible "earthquake storms".

3. MATERIALS AND METHODS

This research was carried out using a multidisciplinary approach including geomorphological observations collected during a 0.6 km snorkel survey,

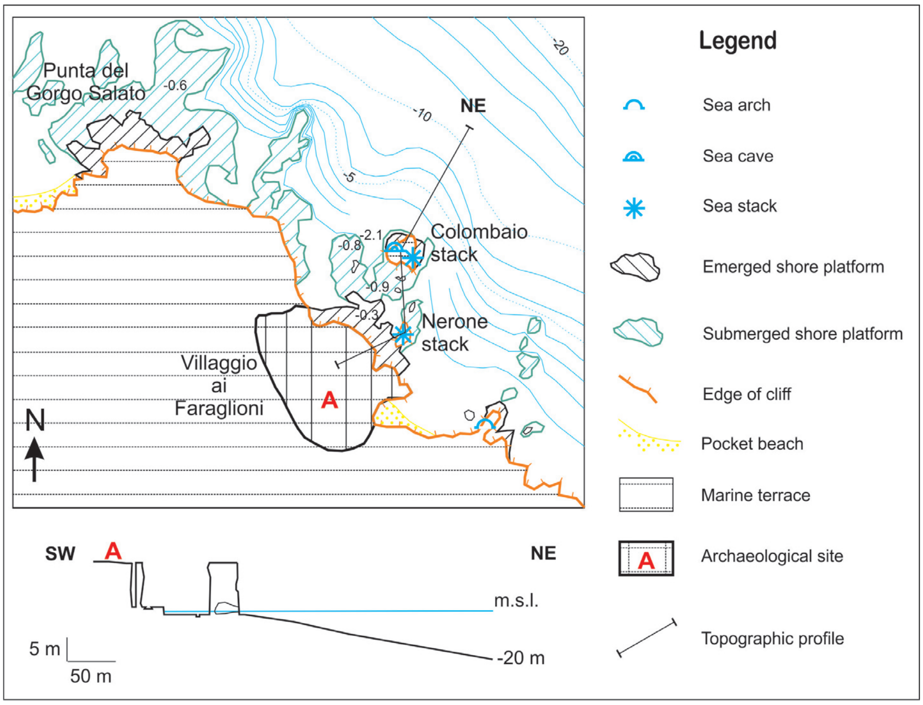

FIGURE 3. Geomorphological and bathymetric map of the Faraglioni area and cross section of the coast between the stack and the archaeological village. Data taken from Geoportale Regione Sicilia, Infrastruttura dati territoriali – S.I.T.R., www.sitr.regione.sicilia.it. Isobaths were redrawned from Navionics data.

integrated by inland geomorphological surveys.

The snorkel survey was carried out along a track of 0.6 km, in the coastal sector facing the Faraglioni village (Figure 1, 3). The survey adopted the protocol suggested by Furlani et al. [2014a, 2017a,b]. The survey was carried out using snorkel observations during the 5th of July 2017 at about 1 m from the shoreline. A specially designed raft was used to house all the surveying equipment during the snorkeling activities. One GoPRO Hero5 camera, located in a semi-submerged dome, allowed to collect time lapses of large part of the observed coast, both above and below the sea level.

Bathymetric data were collected using a Digital Depth Sounder with 0.1 m resolution and they were compared to sea level change curves the central Mediterranean area [Lambeck et al., 2011].

The measures of elevations were compared to the local tide using data provided by ISPRA at the tidal gauge of Palermo (Lat: °37'29.16'', Long: °30'23.46'', http://www.mareografico.it), but differences were lower than 0.05 m during the surveying time. Wind direction and velocity during the surveying period were collected at the same station.

The map with geomorphological elements was created following the symbols suggested by Biolchi et al. [2016] and Mastronuzzi et al. [2017].

4. RESULTS

4.1 TOPOGRAPHICAL AND BATHYMETRIC DATA

The topographical and bathymetrical characteristics of the site are described in Figure 3. The coastline nearby the stack is indented, with alternated small headlands and bays, from Punta Gorgo Salato toward Southeast. The emerged topographical features, such as the shore platform, continue below the mean sea level, as marked by isobaths, roughly following the direction of headlands and bays. The coastline is characterized by alternating sectors of vertical 20 m-high plunging cliffs and other sectors with a shore platforms at the cliff toe. The deposits at the cliff toe are mainly constituted by blocks, cobbles and pebbles collapsed from the cliff and rounded by marine processes. Cliffs are cut in columnar basalts, octagonal in shape and about 1 meter in size. They generate high slopes, often vertical. The vegetation on the terrace is Mediterranean, with shrubs and bushes, while on the cliffs is almost absent.

4.2 THE COLOMBAIO STACK

The Colombaio stack is 17 m long and 11m large, with a subcircular shape. The top of the stack is at an altitude of 17 m a.s.l., roughly at the same height of the archaeological site. The stack is cut on columnar basalts at the eastern side and basalt breccia at the western side.

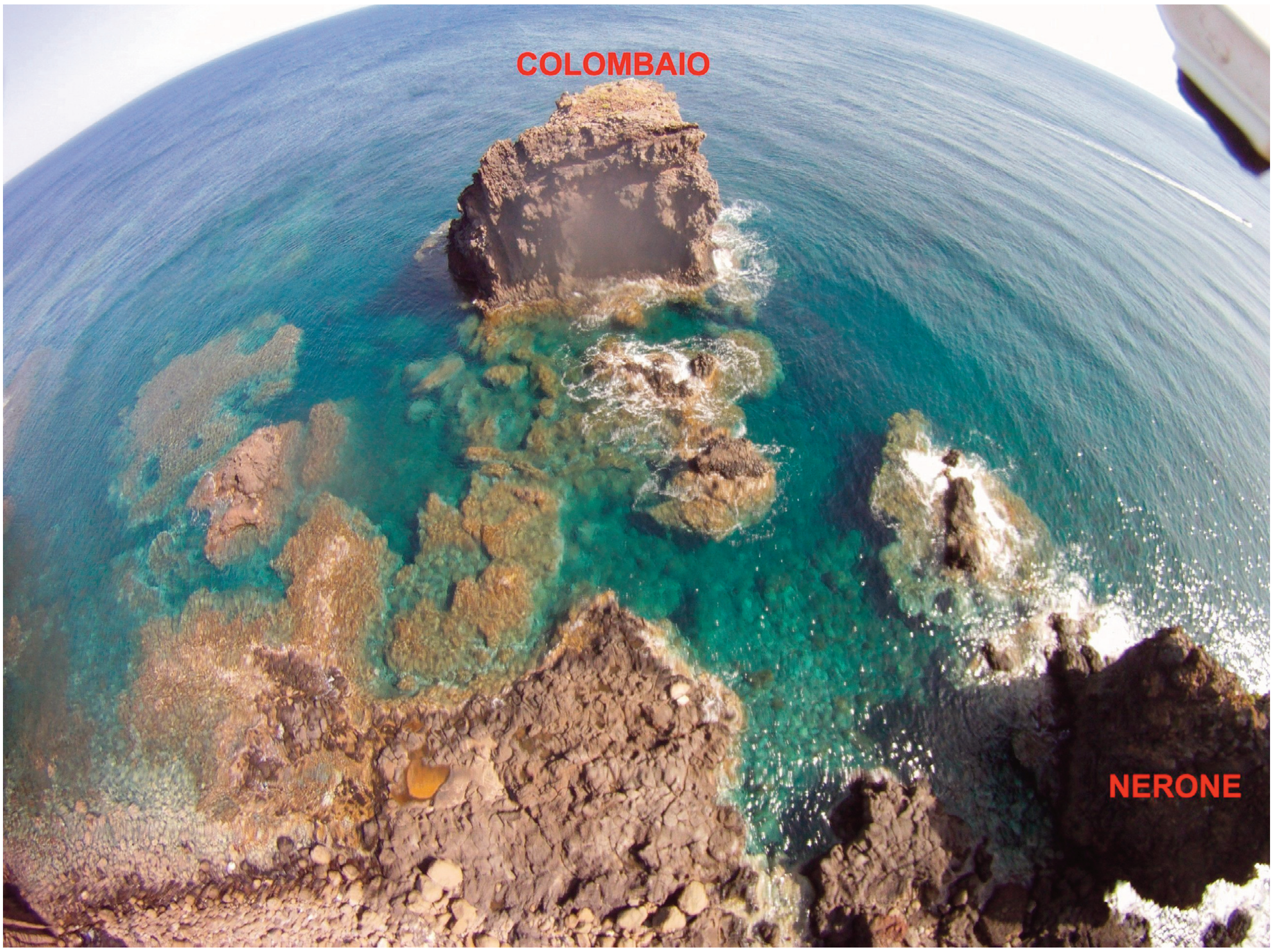

FIGURE 4. Aerial view of the Colombaio stack and the nearby seabed. The area between the coast and the stack is occupied by partially submerged shore platform. Bottom right the Nerone stack.

The stack is located about 60 m from the cliffs and the maximum depth in the transect between the stack and the coast is -2.1 m m.s.l. (Figure 3). The sea bottom is extremely irregular, due to the presence of many basalt blocks of irregular shape. Several rocks emerge, maximum few decimeters in height, on the sea surface between the stack and the coastline (Figure 4).

Few meters from the cliffs, a small stack, called Nerone, roughly lies at the same altitude above mean sea level (Figure 3).

Inside the stack we discovered a sea cave (Figure 5). It develops at the contact between volcanic breccia and the columnar basalts. The entrance opens on the northern side of the sea stack. The height of the entrance is about 6 m, while the width is maximum 2 m. The cave is 14 m long and 6 m large. The maximum height is 9 m m.s.l., while the maximum depth is -2.5 m m.s.l.. The walls of the cave show the surfaces of detachment of blocks that collapse at the sea bottom. Below the sea level, the walls are rounded, while the seabed is covered by well-rounded pebbles and cobbles.

Along the southeastern side of the stack, a fracture cuts the columnar basalts forming a narrow sea arch-like landform. On the top of the stack, ceramics and other archaeological remains are still visible (Figure 5c, d).

4.3 COASTAL OBSERVATIONS

From a geomorphological point of view, a wide marine terrace lies in the southwestern part of the study area (Figure 3). The archaeological site lies at the seaward edge of the terrace and is partly cut by cliff retreat, as testified by active sea cliff about 20 m high. Toppling and rock falls are mainly responsible of retreat processes. At the cliff toe, rounded blocks are reworked by marine processes. A shore platform occurs around the sea level, 5-30 cm above sea level landward, and 5-90 cm below sea level seaward. Part of the shore platform slightly emerge and they form very small islets covered by seawater only during storms. The seaward platform is partly lacking and it creates a sort of submerged patchwork (see Figure 3, 4 and 5). It develops up to the Colombaio stack (Figure 5).

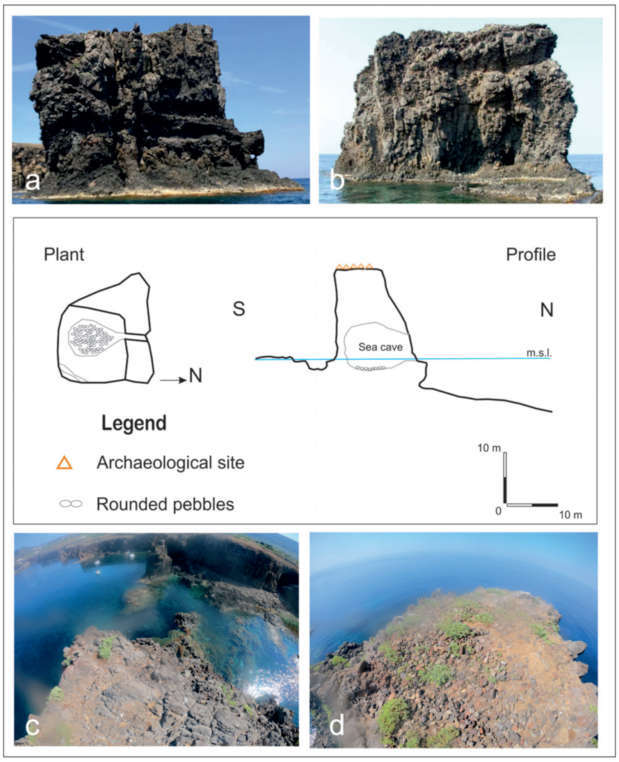

FIGURE 5. Views of the Colombaio stack: a) Northeastern side; b) Southwestern side; in the middle part of the figure, plant and N-S profile of the Colombaio stack; c) the southern part of the top of the stack and view landward; d) the northern side of the top of the stack. Several ceramic remains occur at the top.

Several decametric to metric coastal landforms occur on the landward platform, such as tidepools, centimetric holes, etc. Moreover, a dense network of joints cut the platform, mainly in hexagonal forms that follow the edges of the basalt columns.

5. DISCUSSION AND CONCLUSION

The Faraglioni Village is considered one of the best preserved Middle Bronze Age site of the Mediterranean area [Counts and Tucks, 2009], but many doubts concern its seaward border, because of the lacking of data concerning the retreat rates of local sea cliffs. New data collected at the Faraglioni archaeological Village allowed to reconstruct its palaeogeography and provide some constrains on its evolution since the Middle Bronze Age. Archaeological remains have been found at the seaward edge of the cliff and on the top of the stack, locally called Colombaio, therefore archaeologists supposed that there were a connection with the mainland, since Colombaio lies about 60 m from the shore. The cliffs at the stacks and the mainland are cut in columnar basalts, while there are many submerged or slightly emerged rocks belonging to the shore platform, in the sector between the stack and the mainland. The evolution of stacks and sea arches, can be very dramatic, leading to their complete disappearance [Shepard and Kuhn, 1983; Sunamura, 1992], moreover beyond the possibility to forecast the collapsing, such as the case of Azur Window at Gozo, Malta [Gatt, 2013]. For the same reason, the reconstruction of the paleogeography can be very difficult. Here, the presence of a well-preserved archaeological site close to the stack allow us to have some useful constrains in the evolution of the area.

Around 3250-3200 BP the inhabitants suddenly abandoned the site, leaving all their belongings. Following Spatafora and Mannino [2008] and Spatafora [2009], this sudden flight is related to two hypotheses: a hostile invasion from the sea, or a natural disaster that induced the population to find a safer place. Literature suggested that most probably there was a natural bridge between the stack and the coast, and that it collapsed as a result of a natural catastrophic event, such as an earthquake [e.g. Spatafora and Mannino, 2008].

The presence of the human-made site could also have altered the normal erosion of the cliff-platform system, but we have no data to estimate a precise value, e.g. removal of the scares vegetation at the cliff top or concentrated channel surface runoff, as studied in many modern sites around the world [Kuhn and Shepard, 1984]. Erosive action on the lava cliffs is affected by the vertical joints of the columnar basalts favored by the natural tendency of fracturing at right angle to the joints. Thanks to the geographical and climate setting, storm waves directly hit the cliffs, causing high pressure shocks. Norrman [1980] suggested that the vibrations produced by waves can fragment into blocks of bed thickness size, or in this case of column thickness size. Blocks at the cliff toe can be rounded by marine erosion or are sucked out offshore. The shore platform, both submerged and emerged (Figure 3), is partly covered by a small beach with rounded pebbles and cobbles. Norrman [1980] suggested that blocks can be carried away by the swash within less than a few months. The 20 m-high cliffs are often subject to collapses due to landslides (Figure 5c). The destructive effects can be strongly increased by storm waves (Figure 6), until the extreme consequence of rock-falls and collapses. Surface erosion is mainly controlled by mechanical weathering,

FIGURE 6. Images collected during severe storms in the study area. Waves can exceed the top of the cliff near the stack (Photos Usticasape).

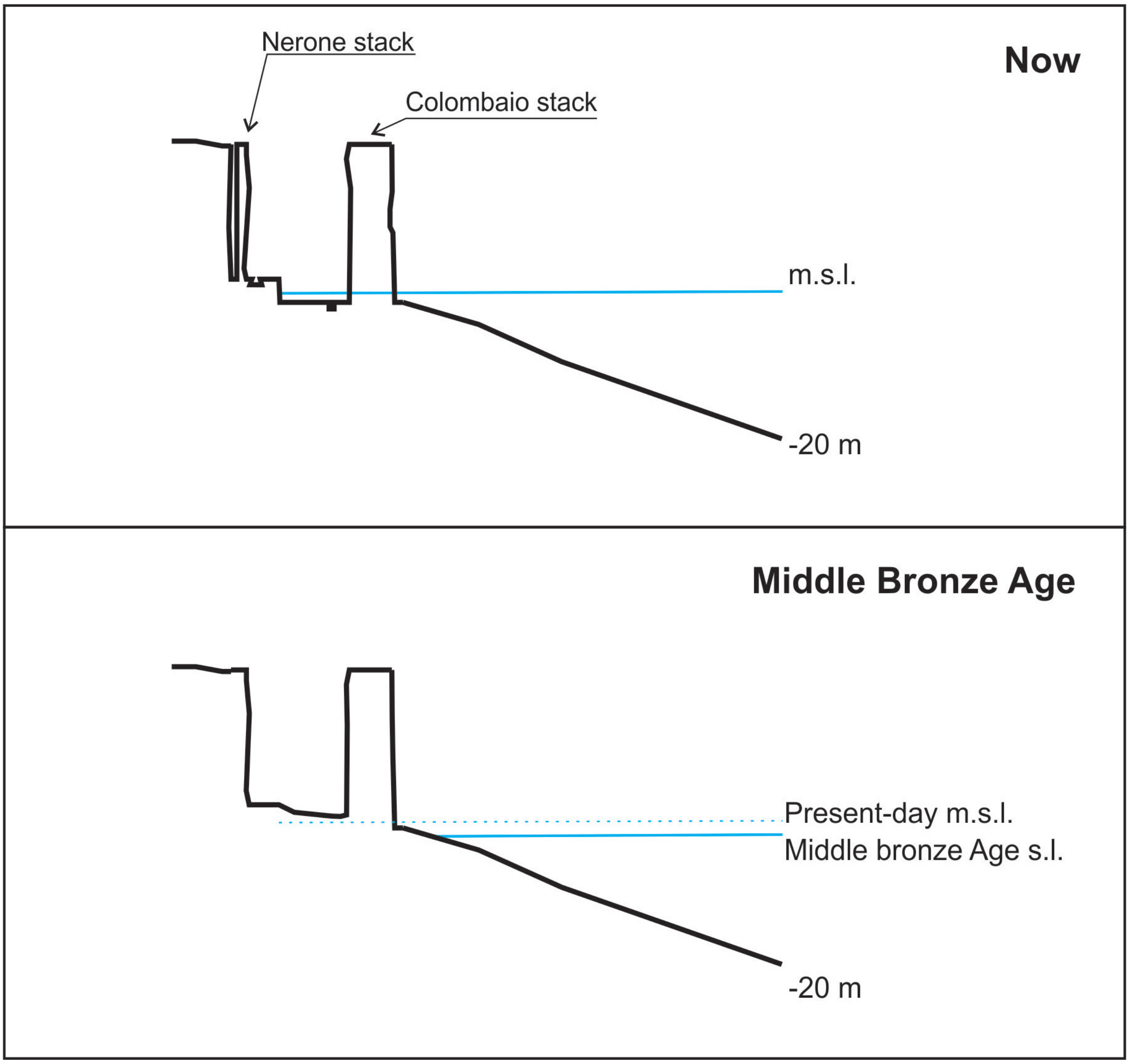

FIGURE 7. Palaeogeographic reconstruction of the evolution of the Faraglioni area. In the Middle Bronze Age (3.5 ka BP) the sea level was -2.2 m lower than present-day sea level. The Nerone stack probably did not exist because it was part of the cliff. The shore platform between the cliffs and the Colombaio stack was completely emerged because the sea level was significantly lower than the shore platform, both the emerged and the submerged one.

such as salt weathering, and by subaerial processes related to gravity, such as slab failure.

The lateral tensile stresses in the rock free-face produce vertical joints that will begin to open until when the mass of the slab exceeds the support afforded by the area of contact between the slab and the underlying main rock mass. Slab failure will occur by toppling or rock falls. As the cliff face retreats, a shore platform develops at the cliff toe (Figure 3).

The cliffs at the archeological village show different stages of the breaching process related to the lifecycle of a coastal natural cliff. The process is controlled by the development of jointing and sea wave erosion.

The Colombaio stack is at the end of the process controlled by slab failure. It developed as a result of sea wave deflection towards the stack which resulted in greater erosion along a weak spot within the headland. Erosion along joints produced a void that became larger by slab failure. The rock mass is partially uniform, therefore the response to geomorphological processes is partially variable.

The stack has experienced continuous mass failure never documented. The condition of the base of the stack, despite wave action, is resistant. Rock failures around the stack are not random, but follows processes associated jointing pattern and natural cliff retreat, as testified by the small sea arch in its southeastern part, and the sea cave within the stack. The latter develops along the contact between columnar basalts and basalt breccias. Because of depth conditions (Figure 3) in front of the studied cliffs there is almost no wave refraction, therefore the alongshore component in oblique waves will only be slightly reduced in the swash.

We suggest that it is not necessary to hypothesize the occurrence of a bridge, both natural or human-made, first because there is not a large amount of material at the cliff toe, then because during the Middle Bronze Age, about 3400-3200 BP, the sea level was lower than today and the stack was connected to the mainland through an emerged path. The latter roughly corresponds to the shore platform, that now is partly emerged and submerged (Figure 7).

The maximum depth measured in the channel separating the stack from the mainland is -2 m m.s.l. During the Middle Bronze Age, the sea level was 2.2 m lower than today, adding the galcio-hydroeustatic component [Lambeck et al., 2011] and the tectonic component of 0.23 mm/a suggested by Furlani et al. [2017]. Therefore, a small path of rock, emerging above the sea level, connected the foot of the sea cliff with the stack. The access to the stack was therefore possible also without a human-made bridge, or the presence of a sea arch. On the contrary, considering the current distance from the cliff, the Nerone stack was most probably part of the terrace during the Middle Bronze Age. However, it is impossible to exclude the occurrence of co-seismic events, or earthquake storms, as suggested by several authors, e.g. Mourtzas and Kolaiti [2017] in the Aegean Sea, that could have suddenly modified the topography of the coastline.

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