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A GEOSITE TO BE SAVED: THE TYRRHENIAN FOSSIL DEPOSIT ON THE ISLAND OF USTICA

SUMMARY

During the 1960s, fossil beds characterized by a tropical-sea malacofauna were discovered by G. Ruggieri and G. Buccheri in the Island of Ustica, on the southern slope of Falconiera hill, 32 m asl. Thanks to the presence of *Strombus bubonius* and other Senegalese guests, the authors estimated that the molluscan fauna had lived around 125,000 years ago, during the Tyrrhenian stage. Recently on the initiative of the "Centro Studi e Documentazione Isola di Ustica", a research has been initiated to verify the persistence of sand-layers mixed up with Tyrrhenian fossils, even though, in the last 50 years, that area has undergone great changes, because of earthworks which have sealed the deposit. The new research led to the discovery of a fossil assemblage formed by 22 taxa (16 species of gastropods and 6 of bivalves), characterized by the presence of some Senegalese guests and other accompanying species that can be associated with the Eutyrrhenian subunit (MIS 5.5). This is the main subject of this note, along with the suggestion to preserve what remains of the Ustica Tyrrhenian deposit.

Key-words: Ustica, Tyrrhennian, fossils, geosite.

RIASSUNTO

Un geosito da salvare: Il deposito fossilifero Tirreniano dell'isola di Ustica. Nel corso degli anni '60 G. Ruggieri e G. Buccheri scoprirono un giacimento fossilifero, caratterizzato da una malacofauna tropicale, nell'Isola di Ustica, sul versante meridionale della Falconiera, 32 m s.l.m. Grazie alla presenza di *Strombus bubonius* e di altri ospiti Senegalesi, i due ricercatori stimarono che quella fauna era vissuta circa 125.000 anni fa, durante il Tirreniano. Ora, per iniziativa del Centro Studi e Documentazione Isola di Ustica, è stata condotta una ricerca per verificare la persistenza di livelli contenenti fossili del Tirreniano, nonostante quella zona abbia subito profondi cambiamenti e lavori che hanno sigillato il giacimento. La nuova campagna di ricerche ha portato alla scoperta di un'associazione fossile formata da 22 taxa (16 gasteropodi e 6 bivalvi), caratterizzati dalla presenza di ospi-

ti Senegalesi e altre specie accompagnatrici che possono essere associate all'Eutirreniano (MIS 5.5). Questo è l'argomento della presente nota, assieme al suggerimento di preservare quel che rimane del deposito Tirreniano di Ustica.

Parole-chiave: Ustica, Tirreniano, fossili, geosito.

INTRODUCTION

In the area of Ustica, the southern slope of the Falconiera tuff cone (maximum height 157 m asl) and the underlying Cala Santa Maria harbor, located on the eastern side of the island, are sites of significant paleontological importance (Fig. 1). During the second half of the 1960s, fossil beds characterized by the presence of a typical, tropical-sea malacofauna were discovered in this area. This malacofauna colonized the Mediterranean over a long period when the weather was warm, corresponding to the geological stage called Tyrrhenian, which culminated around 125,000 years ago with the Eutyrrhenian subunit (RUGGIERI & BUCCHERI, 1968). The Tyrrhenian fossil deposits, which refer to the previous interglacial period, contain a rich fauna of corals, algae and molluscs with *Strombus bubonius* and other species that usually accompany the warm water Senegalese fauna (Fig. 2).

Recently, on the initiative of the "Centro Studi e Documentazione Isola di Ustica", a research has been initiated to verify the persistence, in that same area, of the typical Tyrrhenian fossils and possibly to find others not previously reported. This was not an easy task since, in the last 50 years, the southern slope of Falconiera has undergone great changes, because of earthworks

Fig. 1 — Ustica view from satellite (Google Earth). The Falconiera crater is located at the eastern side of the island.

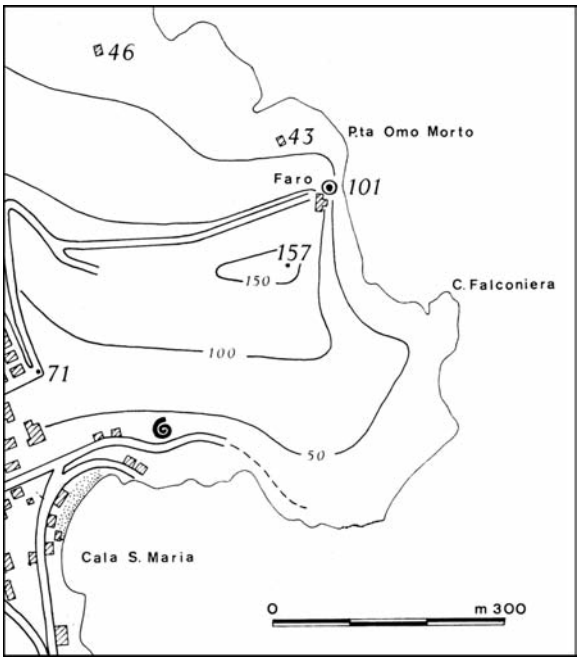

Fig. 2 — The location of the Tyrrhenian outcrop (indicated by a gastropod) on the side of the volcano Falconiera that overlooks Cala Santa Maria, the main port of Ustica (after RUGGIERI & BUCCHERI, 1968).

as the construction of roads, aqueducts, cottages, retaining walls and quays, which have altered the original outcrop and sealed large part of the deposit (Fig. 3). The research led to the discovery of a malacofauna that can be associated with the Eutyrrhenian subunit. This is the main subject of this note, along with the suggestion, for the public administrators of the island, to take environmental protection measures to preserve what remains of that important deposit (FORESTA MARTIN, 2012).

RUGGIERI AND BUCCHERI RESEARCH (1968)

First of all it is necessary to summarize the story of the discovery of the Tyrrhenian level in Ustica, which is the premise of this work. During the mid-sixties, Mr. Pietro Lo Giudice, the librarian of the Institute of Geology at Palermo University, used to go to the island of Ustica, located about 70 km from the coast of Palermo. Having noticed that some shopkeepers sold fossil shells to tourists, sometimes combined in rudimentary artistic compositions, he inquired after their origin. Subsequently, he went to where they had been found at the foot of the southern slope of Falconiera, at the edge of a road called via Mezzaluna (Crescent Street), which had just been built. Realizing the potential paleontological interest of the finds, the librarian picked up some fossils and took them to Giuliano Ruggieri, Professor of Paleontology at Palermo University, as well as the director of the Institute of Geology, and to his assistant Giuseppe Buccheri. They immediately recognized the importance of the find and the need for further studies (RUGGIERI & BUCCHERI, 1968).

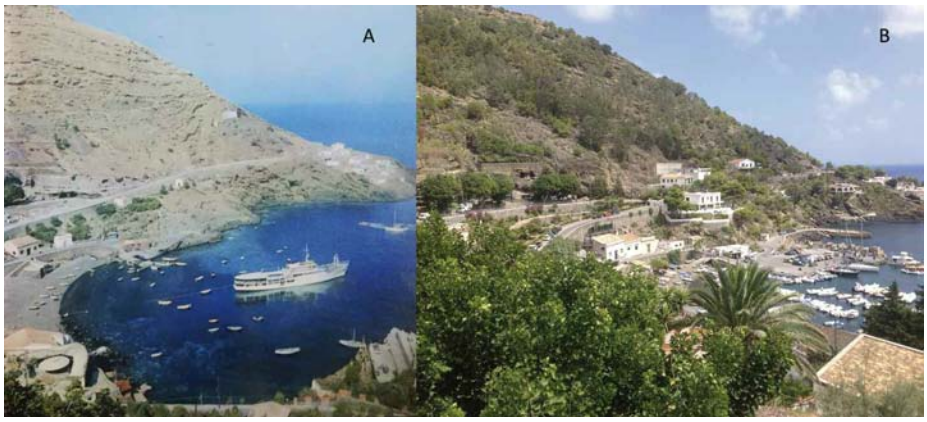

Fig. 3 — Comparison between the southern slope of Falconiera and Cala Santa Maria, as they appeared in the second half of the '60s, during the search of Ruggieri and Buccheri (A), and as it is today (B).

The identification of numerous taxa present in the molluscan assemblage was a discovery of great importance for Ustica and Sicily palaeontology. In fact, together with species common in the Mediterranean, some intruders were also found: those that paleontologists call "Senegalese guests" or "warm visitors" such as: *Strombus bubonius*, *Conus testudinarius*, *Brachidontes puniceus*, *Mamilla lactea*, *Cantharus viverratus*, which still thrive in the tropics, especially in the warm coastal regions of West Africa, but which are extinct in our seas.

Thanks to the presence of these thermophilic species, the two researches estimated that the Mezzaluna molluscan fauna had lived around 125,000 years ago, at the time of the interglacial period that preceded the last ice age, during the chronostratigraphic stage called Tyrrhenian. At that time -with average global temperatures higher than those of the present day, with less polar and mountain ice and higher sea levels, with surface ocean currents differently oriented than today- some tropical fauna had colonized the Mediterranean, penetrating through the Strait of Gibraltar.

During some visits to Ustica, Buccheri was able to better define the Tyrrhenian fossil deposits, which resulted as having formed a layer of sand 80 cm thick, placed between tuff layers of the Falconiera volcano, at an altitude of about 32 m asl, immediately above the Cala S. Maria, the island's main port. The authors concluded that the beach had formed on the south eastern side of the Falconiera crater, after the eruptive activity had ended and the volcanic edifice had already partly crumbled (RUGGIERI & BUCCHERI, 1968) (Fig. 4). This hypothesis was confirmed many years later, thanks to precise radiometric

dating effected on Ustica's volcanic rocks made by some volcanologists from the Vesuvius Observatory in Naples (DE VITA, 1993; DE VITA *et al.*, 1998).

Ruggieri and Buccheri were the first researchers to discover a Tyrrhenian layer on the island of Ustica, and this find has enriched the reconstruction of other coeval layers found in other Mediterranean areas and, in particular, in Sicily (RUGGIERI *et al.*, 1969).

The taxonomic study carried out by Ruggieri and Buccheri allowed the identification of 112 taxa as follows: 89 gastropods, 22 lamellibranches, 1 Monoplacofora (RUGGIERI & BUCCHERI, 1968).

THE NEW RESEARCH CAMPAIGN

The new campaign of paleontological research, carried out by Franco Foresta Martin on behalf of the Centro Studi e Documentazione Isola di Ustica (Foresta Martin, 2012), led to the observation that the ancient Tyrrhenian coastline which originally carved the southern slope of Falconiera, 32 m asl, was almost entirely enclosed by walls of reinforced concrete and various con-

Fig. 4 — The southern side of Falconiera seen from the sea: the Tyrrhenian beach line is located at the level of white buildings at the foot of the escarpment.

structions (Fig 5). To make matters worse, the only gap that exists today to reach the field is a small clearing at the edge of the Coast Guard building, which is used as a storage area for harbour scrap and various tools. However, some layers of sand formed by lapilli erupted from the Falconiera volcano and minute fragments of shells, can still be found.

The new excavations made it possible to find a fossil assemblage located 32 m asl; and a few other pieces located at 10 m asl, just above the current shoreline. The fossil assemblage collected 32 m asl is formed by 22 taxa divided into 16 species of gastropods and 6 species of bivalves, as listed below (Fig. 6).

Gastropods
Haliotis sp. ind.
Diodora gibberula (Lamark, 1822)
Diodora sp. ind.
Patella ferruginea Gmelin, 1791
Patella rustica Linneo, 1758
Patella sp. ind.
Osilinus turbinatus (Born, 1778)
Bolma rugosa (Linneo, 1767)
Cerithium cf. *vulgatum* (Bruguière J.G., 1792)
Cerithium lividulum Risso, 1826
Luria lurida (Linneo, 1758)
Hexaplex (Trunculariopsis) trunculus (Linneo, 1758)
Columbella rustica (Linneo, 1758)
Pisania sp. ind.
Conus mediterraneus Hwass in Bruguière, 1792
Conus testudinarius Hwass in Bruguière, 1792

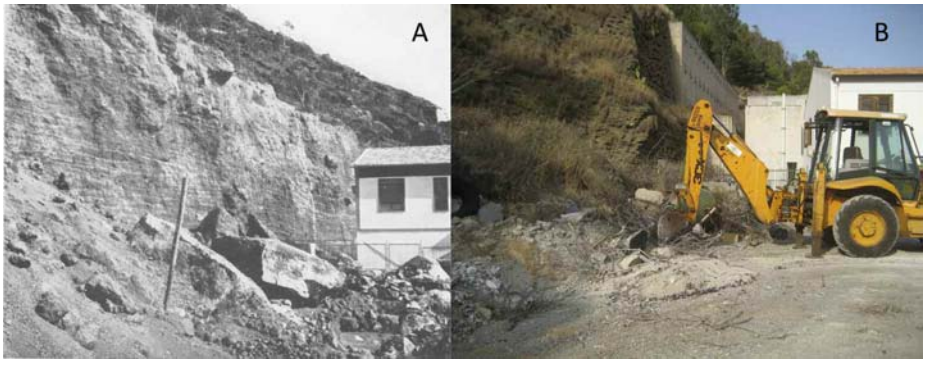

Fig. 5 — Comparison of the outcrop photos (at the foot of the wall tuffs), during the Ruggieri and Buccheri research (A) and today (B). The fossils are today largely sealed by walls of reinforced concrete; while the site is cluttered with scrap metal and tools.

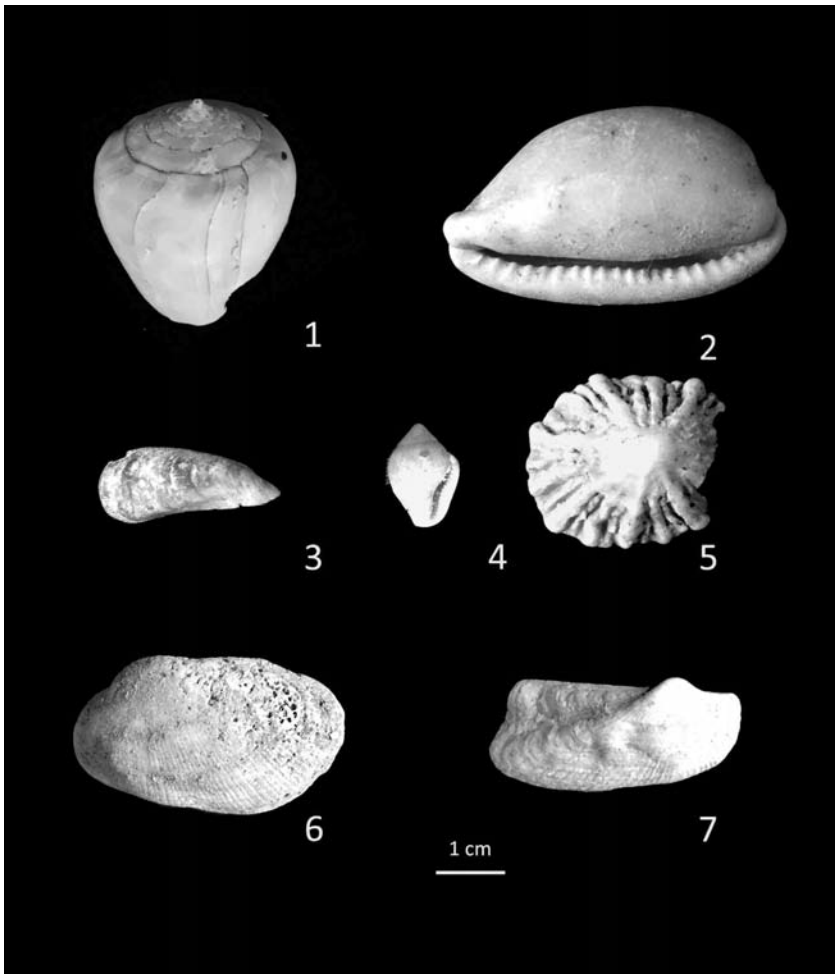

Fig. 6 — Specimens found in the new excavations. 1) *Conus testudinarius* Hwass in Bruguière, 1792; 2) *Luria lurida* (Linneo, 1758); 3) *Brachidontes puniceus* (Gmelin, 1791); 4) *Columbella rustica* (Linneo, 1758); 5) *Patella ferruginea* Gmelin, 1791; 6) *Barbatia barbata* Linneo, 1758; 7) *Arca noae* Linneo, 1758.

Bivalves

Arca noae Linneo, 1758
Barbatia barbata Linneo, 1758
Brachidontes puniceus (Gmelin, 1791)
Beguina calyculata Linneo, 1758
Ctena decussata (O. G. Costa, 1829)
Chama gryphoides Linneo, 1758

Fossils collected 10 m asl
Astroides calycularis (Pallas, 1766)
Arca noae Linneo, 1758
Venus verrucosa Linneo, 1758

The species collected in the new research campaign are fewer in number respect to Ruggieri and Buccheri work, but represent a well-characterized assemblage typical of warm or warm-tempered water, reinforced by the presence of Senegalese guests, such as the famous *Conus testudinarius* and *Brachidontes puniceus*, and individuals classified as accompanying species of the above, reported in areal hot or at least warm of the interglacial period.

Recent studies on epibenthic communities in shallow waters of the Sal Island (Cape Verde archipelago, eastern Atlantic) carried out on transects perpendicular to the coastline, up to 33m bsl, revealed that *Strombus bubonius* lives currently in the waters between 4-9 m bsl, on sandy or gravelly coasts moderately exposed (MORRI *et al.* 2000).

Observations on the hot water Senegalese fauna made in the island of Sal indicate that these species need to survive an average surface temperature of the sea water of 23.5 °C, with seasonal fluctuations of no more than 4 °C and an optimum average salinity value of 35 psu. This work confirms the paleontological studies (PÉREZ-FOLGADO *et al.*, 2004) according to which ocean temperatures in the western Mediterranean, Morocco, and other islands of western Macaronesiane, during the previous interglacial, were higher than the current (ZAZO *et al.*, 2010).

CORRELATION WITH RECENT GEO-VOLCANOLOGICAL STUDIES

The past and recent paleontological research effected on the Ustica Tyrrhenian layer, well accord with the geo-volcanological studies of the island developed in the meantime by various authors (ROMANO & STURIALE, 1971, DE VITA, 1993; DE VITA & ORSI, 1994; CIVETTA & ORSI, 2012). They show that the island of Ustica is the small top of a vast submerged volcanic complex that rises more than 2,000 m from the bottom of the Tyrrhenian Sea.

The origin of Ustica is related to crustal extensional deep faults, generated during the deformational events that accompanied the opening of the Tyrrhenian basin, in the course of the complex interaction between the African and Eurasian plates. This mechanism led to the rise of magma directly from the mantle, thus making Ustica the only volcano of anorogenic origin that emerged from the South Tyrrhenian Sea. This means that it is a volcano that is not tied to the processes of plate subduction, in a geological context

dominated by the orogenic volcanism of the Aeolian Islands. The volcanic rocks of Ustica, mainly of basaltic composition, but with a trachytic component, differ markedly from those of the Aeolian islands, and have affinities with volcanic rocks from Mt. Etna and the Hawaiian islands.

The Ustica volcanic activity began in the Pleistocene, a million years ago or so, on the bottom of the sea, following the formation of several eruptive centres along a fault system oriented NE-SW; then activity concentrated in a main seamount. After about half a million years of underwater eruptive activity, the top of the high volcanic mountain emerged, becoming the first subaerial volcano of the island (now Monte Guardia dei Turchi, 248 m asl). The subaerial volcanic activity continued with the formation of other eruptive centres characterized by various kinds of activity: effusive, Strombolian, explosive. Ustica volcanism recorded as well, around 426,000 years ago, a catastrophic sub-Plinian event, with the formation of a very high eruptive column and the fallout of ash that formed thick pyroclastic deposits. The island's volcanic activity ended around 130,000 years ago, with the explosive Falconiera hydro-magmatic eruption and the formation of a tuff cone whose northern slope then collapsed and fell into the sea, while the southern slope still resists and is the most easily recognizable Ustica crater.

The Falconiera explosion invested a lush colony of corals, *Cladocora caespitosa* species, which lived on the seabed at the foot of Falconiera. The fragments of coral pillows dismantled by that catastrophic event can be found, even today, a few metres downstream from the Tyrrhenian deposit, in the midst of the Falconiera tuffs, on the Cala S. Maria slope. They were collected and sampled during the recent excavations (Foresta Martin, 2012, 2014).

During this turbulent volcanic history there have been several overlapping cycles of marine ingression and regression, which began about 350,000 years ago, resulting from the ups and downs of average global temperatures. This caused the stationing of water on land, with the formation of typical sedimentary terraces, some of which are richly fossiliferous. More recent studies have identified five orders of marine terraces, which are located at heights ranging from about 100 m asl for the oldest and highest terrace, to 5 m asl for the most recent and lower ones (De Vita & Orsi, 1994; De Vita & Foresta Martin, 2000) (Tab. 1).

The Tyrrhenian marine transgression has left, in addition to fossil deposits discovered by Ruggieri and Buccheri on the southern slope of the Falconiera, even a small sedimentary terrace at an altitude of about 30 m asl on the northern side of Falconiera (De Vita & Orsi, 1994; Foresta Martin, 2000) (Fig. 7).

The deposits of the Mezzaluna site containing the fossil assemblage here described, originated during the transgressive-regressive cycle of Eutirrenian

Table.1
Sedimentary terraces of Ustica (after DE VITA & ORSI, 1994).

Order	Height (asl)	Age (ka)
I	80-120	350
II	40-60	240 ± 35
III	30	132 ± 6
IV	10	105
V	5	80

Fig. 7 — The Tyrrhenian marine terrace, about 30 m a. s. l., is located on the northern slope of the Falconiera, on the opposite side of the fossils outcrop.

age, can be correlated with the Marine Isotopic Stage 5e described by SHACKLETON & OPDYKE (1973), today referred as MIS 5.5. Radiometric dating method with the U/Th (based on the decay of certain isotopes of radioactive family of 238U) performed on some specimens of the *Cladocora caespitosa* corals have indicated an age of about 128 ka (DE VITA & ORSI, 1994).

It should be noted that the current height of the ancient marine terraces and lines of beach located in Ustica, as in other places in the Mediterranean Sea, almost never correspond to the level of the seas of the past, because we must take into account vertical movements of the ground (uplift or subsidence) that have occurred in the meantime. In order to have reliable reference points, it is necessary to make comparisons with geologically stable areas,

such as Sardinia, which has been free from vertical movement since the late Pliocene, about 3.6 million years ago. In the case of the Tyrrhenian deposits, the height in Sardinia is about 6-8 m asl (FERRANTI *et al.*, 2006). Therefore, it is reasonable to assume that even the old Ustica Mezzaluna beach was at this level; the fact that it is now 32 m asl is to be referred to the uplift undergone by the island, the effect of geodynamic forces that have taken place on a regional scale. Given that the elevation of the MIS 5.5 marker in the Ustica Mezzaluna site is 32 m asl, and knowing that the average elevation of the MIS 5.5 Sardinia markers is 7 m asl, we can desume that the uplift experienced by this area of Ustica in the last 125.000 yrs is of about: 32m – 7m = 25m. Then, is also possible to calculate the average vertical displacement rate in mm/yr: $25 \cdot 10^3$ mm/$125 \cdot 10^3$ yrs ≈ 0.2 mm/yr; or, if you prefer, 2 cm/century. Obviously this average rate wasn't uniform over time.

A GEOPARK FOR THE USTICA ISLAND

The Mezzaluna paleontological site is an important example of the terraces related to marine istopic Stage 5.5 (MIS 5.5), as evidenced by the discovery of *Strombus bubonius*, a key stratigraphic marker of the last Pleistocene interglacial. This species lives today, along with other forms typical of warm waters, in the Gulf of Guinea and around the Cape Verde Islands, but not in the Canary Islands (MECO, 1972, 1977) because the rise of the cold current along the West African coast blocks its expansion to the north (MECO *et al.* 2002).

This important stratigraphic-ecological aspect adds to the uniqueness of the origin of Ustica and its formation: Ustica is the only emerged anorogenic-type volcano in the Southern Tyrrhenian Sea. It also adds to the wealth of geological forms and volcanic products which are exposed and easily accessible: volcanic plumbing systems, dikes, crater necks, pillow lavas, Hawaiian Style effusive lavas (aa and pahoehoe), lava tubes, marine caves, extinct fumaroles, deposits of ash and lapilli, bombs of various sizes, sedimentary terraces. Characteristics, all of these, which have led some scholars to attribute to the island the definition of "opencast geo-volcanological museum", stressing the value of its geosites for researchers, teachers and students.

This awareness has led to the recent proposal, submitted to the Congress of the Italian Geological Society in 2014, to include the island of Ustica in the European Geoparks Network, the network of geological places selected by UNESCO on the basis of "scientific quality, rarity, aesthetic appeal or educational value " (DE VITA & FORESTA MARTIN, 2014). In this perspective, the recovery and enhancement of the Mezzaluna paleontological site and its

inclusion in guided nature trails, organized by the Marine Protected Area, the Oriented Earth Reserve and Centro Studi e Documentazione Isola di Ustica, are a target to be achieved as soon as possible.

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