

New data concerning the coralligenous atolls of Cap Corse: an attempt to shed light on their origin



*Christine PERGENT-MARTINI, Samy ALAMI, Marina BONACORSI, Philippe CLABAUT, Boris DANIEL,
Sandrine RUITTON, Stéphane SARTORETTO, Gérard PERGENT*

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Christine PERGENT-MARTINI, ALAMI S., BONACORSI M., CLABAUT P., DANIEL B., RUITTON, S., SARTORETTO S., PERGENT G.

FRES 3041, University of Corsica, 20250 Corte, France.

E-mail: pergent@univ-corse.fr

NEW DATA CONCERNING THE CORALLIGENOUS ATOLLS OF CAP CORSE: AN ATTEMPT TO SHED LIGHT ON THEIR ORIGIN

Abstract

A new coralligenous morphotype named 'atolls' was discovered in 2011 in northern Cap Corse (Western Mediterranean Sea). With the aim of inventorying and characterizing these structures, and to attempt to shed light on their origins, two oceanographic campaigns (using e.g. side scan sonar, multibeam echosounder, sparker, ROV and submarine with 3D photogrammetry) were carried out in 2013 and 2014, in this sector, and in the south of the island in search of similar structures.

Off Cap Corse, nearly one thousand atolls were identified between 105 and 130 m depth; the majority of them are situated between 110 and 125 m depth. These atolls are generally grouped (several tens to several hundred) and are to be found in two main sectors, situated between 22 and 31 km from the coast. They occur on subhorizontal bottoms, in rocky depressions occupied by coastal detritic bottom, and are 1 to 2 m thick. The average size of these atolls ranges from 20 to 25 m in diameter, but a few smaller or more extensive structures have been identified. The height of the central core ranges from 0.5 to 3.0 m, the intermediate zone, which surrounds this core, presents a width of about 10 m, and the exterior crown has a width of 1 to 5 m. No atoll was found along the south coast although the topography is similar (bathymetric patterns, presence of a seamount).

Several typologies have been evidenced; these typologies could correspond to atolls at different stages of evolution in relation to phenomena of bioerosion or bioconstruction. Furthermore, the occurrence of 'fossil coralligenous' formations, between 138 and 140 m depth, with still living rhodoliths at the summit, might support the hypothesis of a biological origin, with the original formation occurring during a period when the sea level was lower, several thousand years ago.

Key-words: Coralligenous, Atolls, Rhodoliths, Corsica

Introduction

The coralligenous habitat is considered as a typical underwater seascape and a hotspot of biodiversity in the Mediterranean Sea. It consists of biogenic concretions mainly produced by the accumulation of calcareous encrusting algae, growing in dim light (Ballesteros, 2006; Mичez *et al.*, 2014).

A new coralligenous morphotype was discovered in 2011 off northern Cap Corse (Western Mediterranean Sea) in the vicinity of underwater seamounts (Bonacorsi *et al.*, 2012). These structures, never previously identified in the Mediterranean Sea, are named 'coralligenous atolls' because of their circular shape. They are formed of:

- A massive central core constituted by a massive coralligenous structure;
- A halo of detritic bottom, with few sparse rhodoliths and a large amount of organic debris;
- A peripheral crown consisting of free rhodoliths (pralines) and many invertebrates.

The sector concerned by these atolls is of particular importance as it might be included in the future Cap Corse Marine Natural Park.

Two oceanographic campaigns were carried out in 2013 and 2014 in this sector with the aim of drawing up as exhaustive an inventory as possible of these structures (localisation, number), specifying their morphology and researching into their origin and / or their dynamics.

Material and methods

The study of the atolls was carried out mainly during the CoralCorse cruise, in the summer of 2013 (from 3 to 7 August and from 4 to 8 September). The aim of this cruise, carried out on board the IFREMER oceanographic research vessel Europe, was to produce an exhaustive map of the seabed, from 100 to 150 m depth, in the Cap Corse sector, and also more sporadically in the south of the island (on 23 and 24 August) between Corsica and Sardinia, off Mount Asinara, a sector presenting morphological similarities with the seamounts of Cap Corse.

A range of data acquisition systems were used simultaneously: side-scan sonar (Klein 3000) and a multibeam echosounder (EM 2040) for the cartography and a 2.5 KHz sediment sounder and a sparker (seismic reflection) to identify possible vertical structuration that might explain the origins and dynamics of these atolls; field validation was performed using a Van Veen grab and a Remote Operated Vehicle (ROV).

Complementary investigations were carried out, in the course of the MedAtolls cruise, on 27 July and 2 August 2014, on board the COMEX oceanographic research vessel Minibex. The aim was to characterise the different forms of atoll, identified on the sonograms of the previous cruise, to reconstitute an atoll in three dimensions (photogrammetry) and to identify the main species present. The observations were carried out using a ROV Super-Achille equipped with high resolution cameras and a sample collection system (pincers and basket) and a Remora 2000 submarine equipped with a system for taking photogrammetric images.

Side-scan sonar and multibeam data were processed with the Caribes 3.8® software program and a digital Terrain Model (DTM) and a mosaic (resolution of 0.5 m) were developed. All the data were integrate into a Geographic Information System (GIS; ArcGis 10®; projection Mercator-WGS84).

Several species present on the photographs and video were directly identified and localized on the GIS; for the other species, samples were sent to taxonomists from Aix-Marseille University, IFREMER and the Muséum National d'Histoire Naturelle. The 3D reconstitution of a representative atoll was realised by the COMEX Team.

Results

The mapping of the seabed in the Cap Corse sector, allows identifying almost a thousand coralligenous atolls between 105 and 130 m depth; the majority of these atolls are situated between 110 and 125 m depth. On the other hand, no atoll was observed in the sector between Corsica and Sardinia.

These atolls are generally grouped (several tens to several hundred), around the edge of rocky outcrops, in two main sectors situated between 20 and 30 km to the north of Cap Corse. The map of the distribution of the atolls shows that they are localized on subhorizontal bottoms in rocky depressions (Fig. 1 and 2).

Their average size generally ranges from 20 to 25 m, but a few smaller or more extensive structures were identified. In addition, the central core would appear to vary according to the sector (diameter, apparent height), as do the thickness and the density of the peripheral crown. In certain cases, the central core would even appear to be totally absent.

However, it is difficult to characterize these structures with greater precision on the basis solely of the acoustic sensors (side-scan sonar and multibeam echosounder).

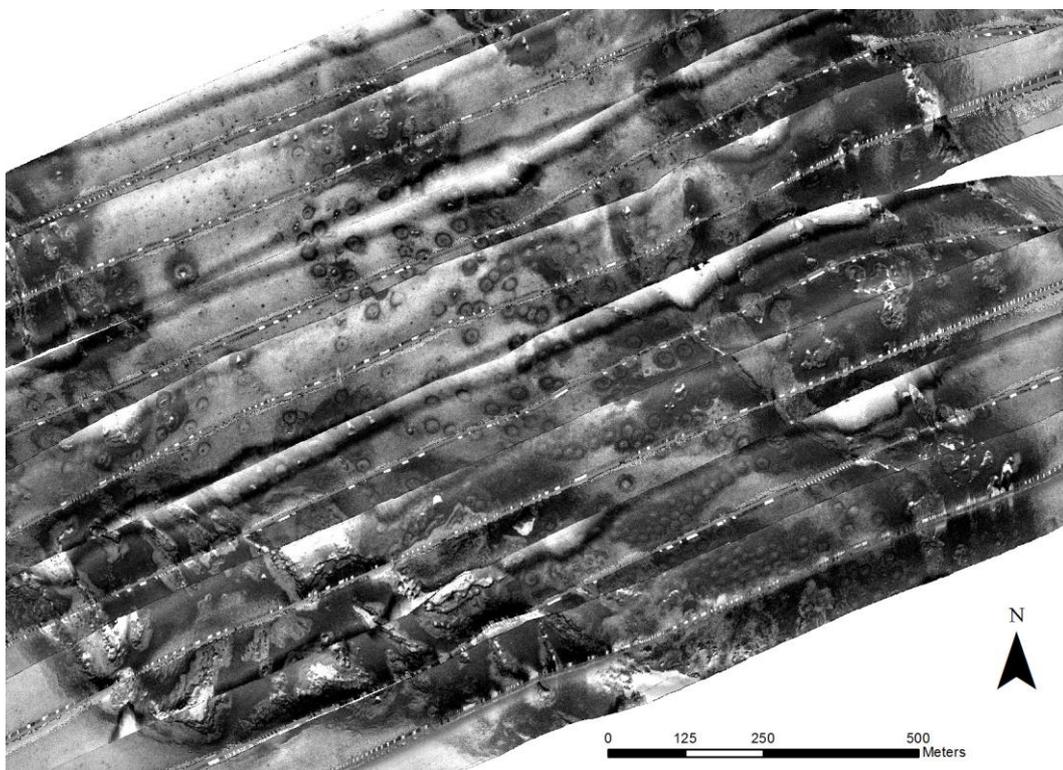


Fig. 1: Example of the concentration of atolls on a mosaic of sonograms.

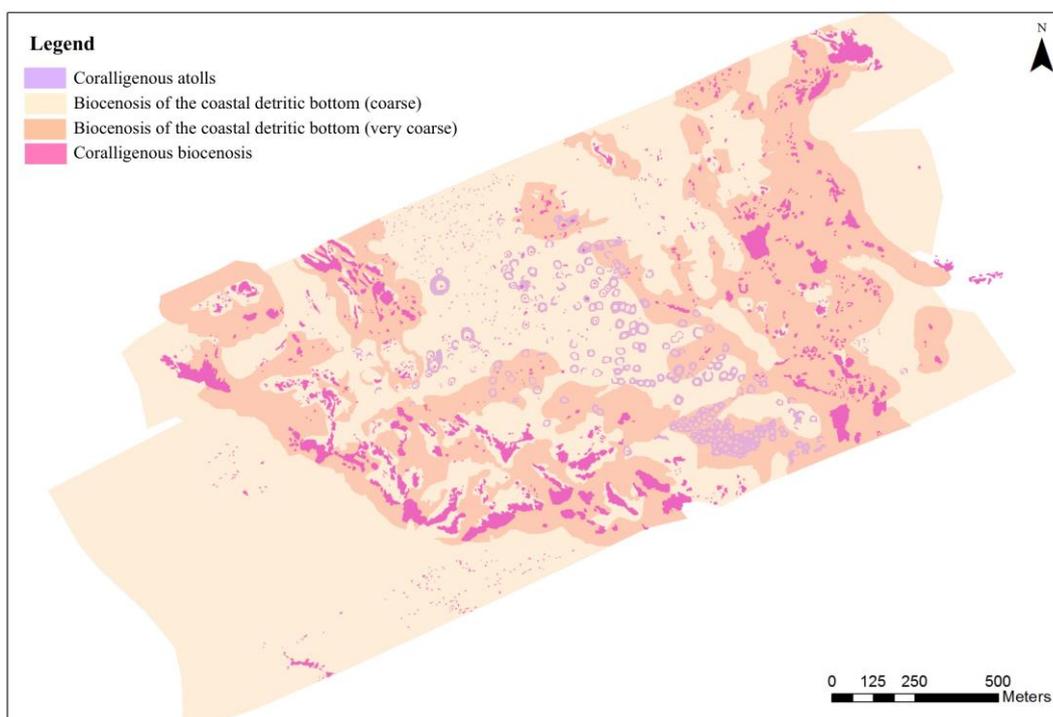


Fig. 2: Map of the main assemblages and bottom types of the zone of concentration of the coralligenous atolls.

Hydrodynamic forces would appear to play a major role in the constitution of the peripheral crown since this type of structure is also observed around the edges of certain rocks; on the other hand, in the presence of very strong hydrodynamic forces (exposed flat rocks, areas characterized by large ripple marks), no atoll was observed. Furthermore, the information obtained by the seismic reflection would appear to indicate that these structures are present on coarse sediment soft bottoms of a thickness of 1 to 2 m. When the sediment layer is thicker (more than 3 or 4 m), no atoll is observed. Several characteristic structures, identified among the mapped atolls, were investigated by means of the ROV and the submarine (Fig. 3). Other observations were also made at greater depths (138 to 140 m) in sectors corresponding to hard substrates and in particular around the 'rock fields' scattered over soft substrates (Fig. 3).

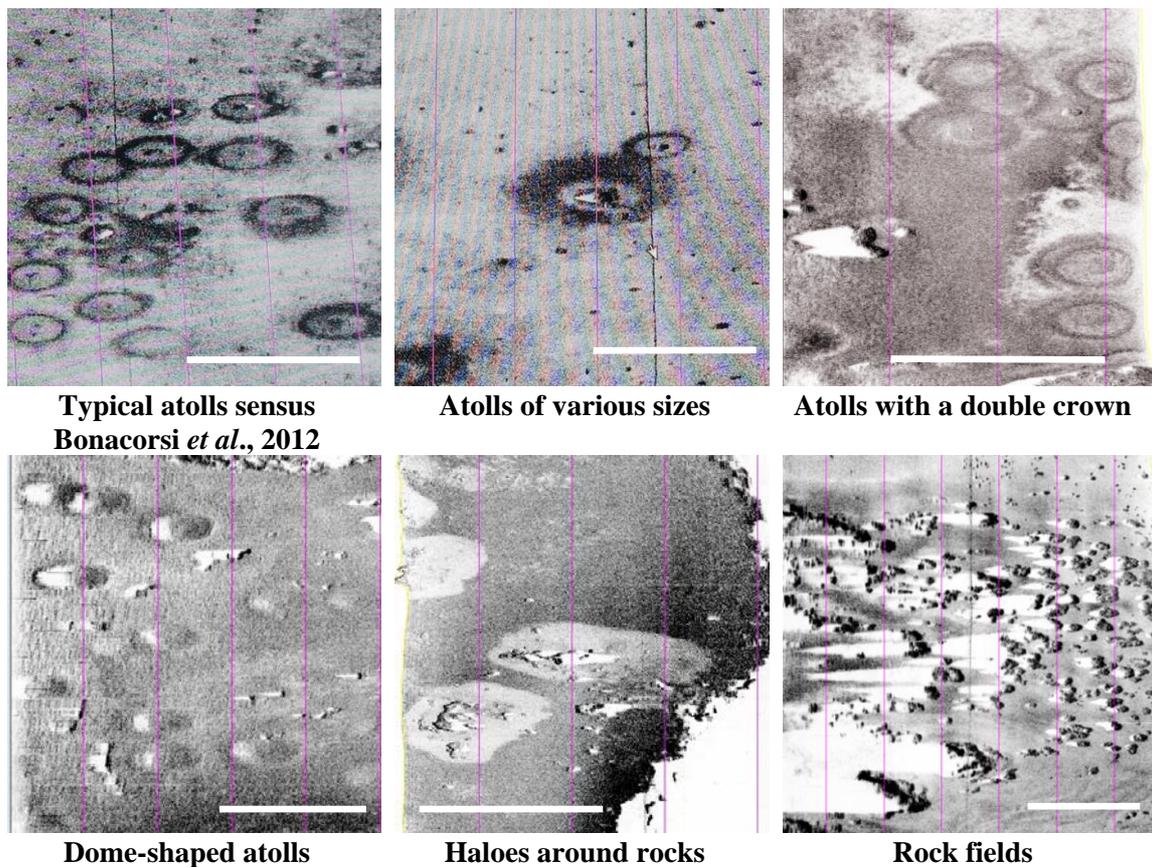


Fig. 3: Different structures observed using side scan sonar; the white line corresponds to 50m.

The central core presents a range of morphologies: it is generally constituted by a massive bio-concretioning in the classic atolls, but it may present extensive erosion with more or less collapsed overhangs around the edges and fragmentation of the core (Fig. 4). In certain cases, the central core is only represented by small, more or less contiguous blocks scattered over the substrate (dome-shaped atolls). On the other hand, the core appears to be raised above the surrounding sediment, and this slope would appear to be present as far as the peripheral halo.

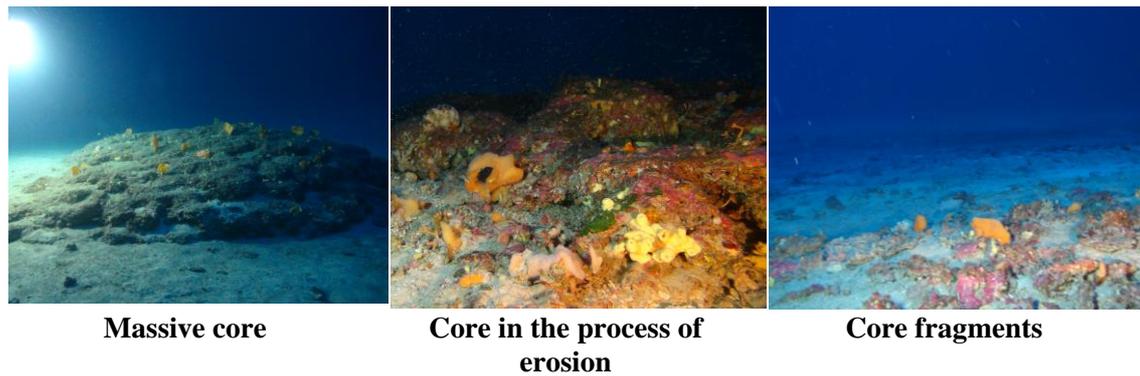


Fig. 4: Different morphologies of the central core observed by means of the ROV.

Between the core and the peripheral crown the sediment appears to be coarse, with abundant biogenic debris.

The peripheral crown is constituted of praline-shaped rhodoliths of various sizes (0.5 to 8 cm), on which numerous invertebrates are fixed (Fig. 5). At certain sites, this crown is subdivided by a band of sand (Fig. 6). Around the crown, various concretioned structures may be observed; they may correspond to the beginnings of a new core.



Fig.5: Accumulation of rhodoliths around the peripheral crown

Fig. 6: Double crown of rhodoliths around the central crown of an atoll

Discussion and conclusion

The analysis of the data collected in the course of the campaigns should continue over the next few months, both in order to be able to offer an explanation of the occurrence of these structures and to understand their dynamic, and to provide an initial inventory of the species present. The three dimensional reconstitution of a 'characteristic' atoll should enable us to better understand its structure and in particular to dispose of a bathymetric record fine enough to confirm the existence of a slope between the core and the peripheral crown.

Similarly, the presence of large colonies of *Callogorgia verticillata* on the periphery of certain atolls should enable us to detect the presence of possible circular currents around these structures (orientation in relation to the prevailing currents).

Nevertheless, in the light of the available data, a tectonic origin would appear to be less and less likely and a biological origin, corresponding to earlier coralligenous formations that might have formed at an earlier period when the level of the sea was lower, is favoured (Waelbroeck *et al.*, 2002; Henderson, 2005). This hypothesis is supported (i) by what would appear to be phenomena of bioerosion, or even of bioconstruction, giving rise to atolls presenting different stages of evolution, and (ii) by the presence

of ‘fossil coralligenous’ formations observed between 138 and 140 m depth, with a few still living rhodoliths at the summit, which had been identified as ‘rock fields’ with the side scan sonar (Fig. 7).



Fig. 7: Coralligenous formation observed at 139m depth.

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