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The enigmatic coralligenous atolls of northern Corsica: possible scars from World War II

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Abstract. In August 2011, during an oceanographic survey, a series of enigmatic coralligenous circles were discovered, between 105 and 125 m deep, off the coast of Cap Corse (Capicorsu, northern Corsica, Mediterranean Sea). Described under the name of coralligenous atolls, this new type of bio-concretion has attracted the attention of scientists and environment managers. Several prospecting surveys have been organized to unravel the mystery of these formations. Hitherto, only a natural and ancient origin (hydrothermal, biological, or hydrodynamic origin) has been considered. In the present paper, the alternative hypothesis of an anthropogenic and recent origin is proposed: the jettisoning of unused, generally unprimed, bombs by US aircraft squadrons based in Corsica, returning from their raids to the European continent, towards the end of World War II (1943-1945).
Keywords: Corsica, coralligenous atolls, bombing craters, jettison zone, World War II.

Résumé. **Les énigmatiques atolls coralligènes du nord de la Corse : possibles cicatrices de la Seconde Guerre Mondiale**. En août 2011, lors d'une campagne océanographique, un grand nombre d'énigmatiques cercles de coralligène ont été découverts, entre 105 et 125 m de profondeur, au large du Cap Corse (Capicorsu, nord de la Corse, Méditerranée). Décrits sous le nom d'atolls de coralligène, ce nouveau type de bio-concrétionnement a attiré l'attention des scientifiques et des gestionnaires de l'environnement. Plusieurs campagnes de prospection ont été organisées afin de percer le mystère de ces formations. Jusqu'à présent, seules des origines naturelles et anciennes (hydrothermale, biologique ou hydrodynamique) ont été envisagées. Nous proposons ici l'hypothèse opposée d'une origine récente et anthropique : le délestage des bombes non-utilisées et généralement non-amorcées, par les escadrilles américaines basées en Corse, au retour de leurs missions vers le continent européen, vers la fin de la Seconde Guerre Mondiale (1943-1945).
Mots-clés: Corse, atolls coralligènes, cratères de bombes, Seconde Guerre Mondiale, zone *jettison.*

1. Introduction

Over the last decades, the increased spatial resolution and accurate positioning capability of hydroacoustic instruments for seabed measurements, i.e., multibeam echosounder (MBES), sub-bottom profiler (SBP), and side-scan sonar (SSS), has led to the discovery of many different seabed structures. Among them, circular or elliptical structures have been described worldwide. Their origin can be either natural (i.e. physical, geological, or biological) or anthropogenic (i.e. dredging, dumping, explosives) (see the review by Diaz-Mendoza *et al.,* 2023).

On August 31, 2011, during the *CapCoral 2* oceanographic survey carried out by GIS Posidonie and the University of Corsica, a new type of coralligenous concretions was discovered, between 105 and 125 m depth, off the coast of Cap Corse (Capicorsu, northern Corsica, Mediterranean Sea) (Bonacorsi *et al.,* 2011, 2012a; Bonacorsi 2012). Circular in shape, these structures have been described under the name of *atolls coralligènes* (coralligenous atolls) (Bonacorsi *et al.,* 2012b). Since then, several multidisciplinary surveys have been dedicated to these bio-concretions to study them and attempt to understand the origin of their formation: *CoralCorse* (2013), *MedAtolls* (2014), *Gombessa 6 'Cap Corse'* (2021) and the most recent, organized by Andromede Oceanology (July 2023) (Bonacorsi *et al.,* 2013, 2014; Clabaut *et al.,* 2014; Deter *et al.,* 2022).

Since 2016, the area where the coralligenous atolls were discovered has been part of a marine park, the *Parc naturel marin du Cap Corse et de l'Agriate*.

To date, only a natural (hydrothermal, biological, or hydrodynamic) and ancient (i.e. several millennia) origin has been considered. Here, we propose and discuss an alternative hypothesis, that of an anthropogenic and recent origin: the jettisoning of unused bombs by US aircraft squadrons based in Corsica, returning from raids to southern Europe, towards the end of World War II.

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2. Characteristics of the coralligenous atolls

Two fields of several hundred coralligenous atolls (more than a thousand according to Andromede Oceanology, https://www.andromede-ocean.com) are localized 22 and 31 km north of Cap Corse. These atolls have a diameter between 20 and 25 m (**Fig. 1a**). The best characterized atolls, according to Bonacorsi *et al.* (2012b, 2013), Clabaut *et al.* (2014), Pergent-Martini *et al.* (2014), Pergent *et al.* (2015), and Denter *et al.* (2022), consist of:

- a fragmented central dome (1 to 2 m in diameter and 0.2 to 0.5 m high), made up of coralligenous frameworks of different sizes (**Fig. 1b**),

- a halo of coastal detrital coarse sediments, ~10 m wide, with a high calcium carbonate content (85 to 92%), with a few scattered free-living rhodoliths (non-geniculate and unattached calcified rhodophytes) and numerous organic debris,
- a peripheral crown 1 to 3 m wide, simple, or split by a sandy strip, made up of coralligenous bank (*coralligène de plateau*), associated with a high density of free-living rhodoliths and numerous invertebrates (e.g. sponges, bryozoans, and echinoderms).

Other atolls lack a central dome. Seismic reflection surveys seem to indicate that the atolls are located on beds of coarse sediment, 1 to 2 m thick. No atolls have been observed on soft bottoms more than 3-4 m thick (Pergent-Martini *et al.,* 2014a, 2014b). A first ^{14}C dating of fragments of bio-concretions taken from the surface of a central dome gave an age of 6 200 years (Pergent-Martini *et al.,* oral communication, *Fête de la Science*, November 2021). Examination of photographs of thin sections of the bio-concretion (courtesy of Michèle Ferrandini) enabled us to determine the main coralligenous-building rhodophytes (*Lithophyllum* of the *stictiforme* group, *Mesophyllum expansum*, *Titanoderma* sp., *Neogoniolithon* sp., *Peyssonnelia* sp., *Polystrata* sp.).

Comparison of two images of the same dome taken in 2014 and 2021 showed an increase in crevices and sedimentation, but no change in the coverage of outstanding sessile species (Deter *et al.,* 2022). Examination of sonograms shows that the contiguous atolls do not merge but overlap (**Fig. 1c**). Their arrangement on the bottom is not uniform: atolls can form strings (**Fig. 1d**) or clusters (**Fig. 1e**).

The atolls are oases of species diversity with, on the central dome and the crown, a very rich benthic fauna (brachiopods, bryozoans, cnidarians, crustaceans, echinoderms, molluscs, sponges) (Pergent-Martini *et al.,* 2014a, 2014b; Pergent-Martini *et al.,* oral communication, *Fête de Science*, November 2021).

3. Characteristics of World War II bomb impact craters

The comparison of aerial photographs of terrestrial areas bombed during World War II with Cap Corse sonograms enabled us to identify several analogies between bomb impact craters and coralligenous atolls, despite the smaller size of the former (usually, 6-12 m in diameter) (Capps Tunwell *et al.*, 2016; Dolejš *et al.,* 2020; Waga *et al.*, 2022):

- in a given area, the impact craters have approximately the same diameter (**Fig. 1f**);

- the arrangement in a string or in a cluster is common, probably reflecting different release conditions (altitude, operational mode) (**Fig. 1f** and **1g**);
- the contiguous craters overlap, reflecting the succession of impacts over time (**Fig. 1h**);
- some craters have a central dome of ejecta (**Fig. 1i**).

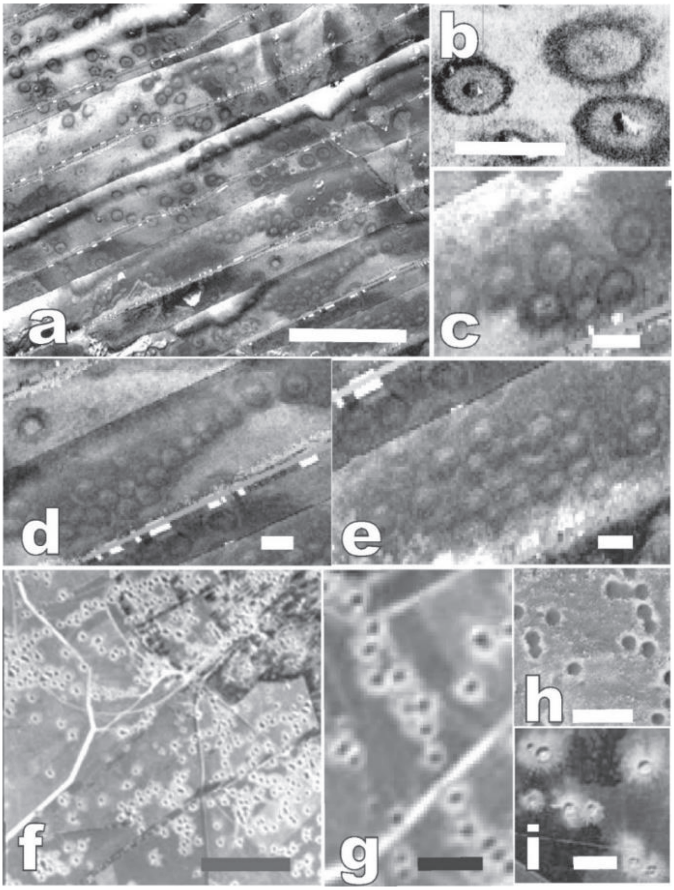

Figure 1. Coralligenous atolls and terrestrial bomb craters**. a:** example of concentration of coralligenous atolls off Cap Corse, on a mosaic of sonograms. **b:** atolls with a central dome. **c:** atoll overlapping. **d:** string of atolls. **e:** cluster of atolls. **f:** aerial view of a terrestrial bombed area from World War II. **g:** a string of terrestrial bomb craters. **h:** overlapping of terrestrial bomb craters. **i:** terrestrial bomb craters with a central dome. (**a-e** from Pergent-Martini *et al.*, 2014; **f, g, i** from © IGNF; **h** from Dolejš *et al.,* 2020, modified). Scale: 250 m (**a**), 25 m (**b-e, g-i**), 100 m (**f**).

The formation of a central dome of ejecta in reaction to an impact is a frequent phenomenon, and the coralligenous atolls with a double crown could result from induced circular waves. This is very well illustrated by a drop falling on the surface of water (**Fig. 2a**). Such features can also be observed in some meteorite impact craters on the surface of the Moon, planets and natural satellites (**Fig. 2b-c**).

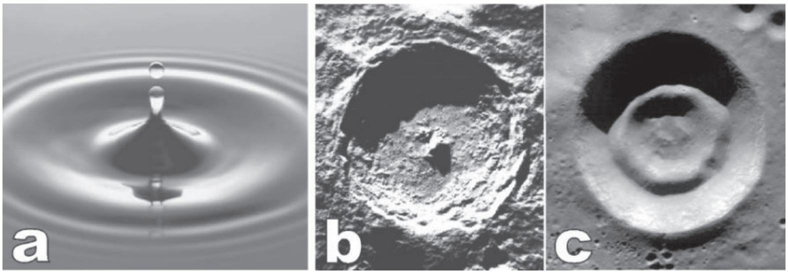

Figure 2. a: impact of a drop on the surface of water with central ejecta and induced circular waves. **b-c**: the *Tycho* impact crater and the *Hesiodus A* concentric impact crater on the surface of the Moon (From Wikimedia commons).

4. Hypotheses of natural and ancient events

Hitherto, only a natural and ancient origin (several millennia) has been considered for the formation of coralligenous atolls.

The first hypothesis is a hydrothermal origin (Bonacorsi *et al.*, 2012b). The expulsion of weakly buried gas in the sediment creates depressions on the seabed, called pockmarks. Discovered in all the world's oceans, their shape is usually circular or elliptical with elongation parallel to the direction of the bottom currents. Pockmarks can be grouped, aligned, linked, or isolated. They are often associated with sedimentary or tectonic structures (channels, faults, diapirs, synclines-anticlines) and preferentially develop when the sedimentary layer is thin (Garlan *et al.,* 2018). In the Mediterranean, environments in which deep water pockmarks preferentially occur are active mud volcanoes, vestigial mud volcanoes and corresponding fault systems, and most abundantly on active faults and submarine slumps (Dimitrov and Woodside, 2003).

The characteristics of Corsican coralligenous atolls are very different from those of pockmarks and hydrothermal sources (black or white smokers; Fouquet *et al.,* 1994). No current emissions of gases or fluids could be demonstrated in Corsican atoll areas (Deter *et al.,* 2021, 2022), which does not exclude the possibility that such emissions could have existed in the past. In southern Italy, for example at Ischia Island, the activity of volcanic underwater CO_2 vents is irregular over time (Foo e*t al.*, 2018; Teixidó *et al.,* 2018).

Circular seabed structures can have a biological origin, e.g. fish nests (Kawase *et al.,* 2013), seagrass beds (Warwick, 2022) or shallow pits created by cetaceans (Nelson *et al.*, 1987), but in view of the depth and characteristics of coralligenous atolls, these origins can be ruled out. Another biological origin, dating back to a period when sea level was much lower than today, has been considered (Pergent-Martini *et al.,* 2014; Deter *et al.,* 2022). During the LGM (Last Glacial Maximum, ~20 000 years ago), the sea level was 120-135 m below the current sea level (Lichter *et al.,* 2010; Collina-Girard, 2012). The coralligenous atolls would have been formed under particular hydrodynamic conditions and at very shallow depths by photophilic calcified rhodophytes such as the *Neogoniolithon brassica-florida* reefs described in southern Tunisia (Denizot *et al.,* 1981; Pergent *et al*., 2009; Langar *et al.,* 2011). However, *N. brassica-florida* reefs are thermophilic formations, today confined to the warmest regions of the Mediterranean (Boudouresque, 2003), and their presence in Corsica near the LGM is unlikely. Furthermore, no shallow formation similar to the coralligenous atolls has to date been discovered in the Mediterranean and the assemblage of calcified rhodophytes identified on the thin sections (see section 2) is characteristic of coralligenous concretions, therefore of a deep habitat.

The more or less large size and the totally fragmented state of the central domes has been attributed to a biological process of erosion. However, bioeroding organisms do not cause this type of dismantling of coralligenous formations. Sponges (*Cliona* spp.) and sea urchins (*Echinus* spp., *Sphaerechinus granularis*) erode the outcrop surface while bivalves (*Lithophaga lithophaga*, *Petricola* spp.) bore galleries (Sartoretto and Francour, 1997; Ballesteros, 2006; Boudouresque *et al.,* 2017; Gennaro *et al.,* 2020). Finally, a bottom current origin should be excluded because, at more than 100 m depth, currents are unidirectional rather than swirling.

5. A new hypothesis: a recent and human-driven event

Based on **(i)** the similarities noted between the fields of coralligenous atolls and the terrestrial bombed areas of World War II, and **(ii)** the analysis of documents relating to the activity of the US aircraft squadrons, based in Corsica, towards the end of this war, we propose an alternative hypothesis to a natural and ancient event: the jettisoning of unused unprimed bombs towards the end of World War II (1943-1945), i.e. a recent and anthropogenic event.

5.1. Structural arguments

The distribution of coralligenous atolls is similar to that of bomb craters. The clusters of atolls would correspond to a grouped or low altitude drop and the aligned atolls to a string drop at high altitude. In areas with high densities of atolls, most have exactly the same diameter, which is difficult to explain by a natural cause but not at all with the hypothesis of bombs of the same calibre.

The wider diameter of the coralligenous atolls (20-25 m) compared to that of bomb craters (6-12 m) may be due to the characteristics of the marine environment (water, soft substrate) and the fact that unprimed bombs penetrate the substrate intact. The average speed of fall of World War II bombs (usually, 100 to 500 kg) was mainly a function of the altitude of release (e.g. 6 000 m: 300 m/s and 600 m: 150 m/s) (Ley and Schaefer, 1941). This speed must have been considerably reduced by the impact on the sea surface, but it would have had to remain sufficient to penetrate the soft substrate.

Neighbouring atolls do not merge, but overlap in a defined order with, at the end of the series, an entire atoll (which would be the last formed) as in the case of bomb impacts. The presence of a central dome and its fragmented state are consistent with impact craters with a central dome of ejecta. The presence or absence of the central dome and its variable size would be linked to the conditions of the impact (thickness of the sediment, and type, speed, and angle of penetration of the bomb). The ^{14}C dating of organisms taken from the surface of a dome, which indicates more than 6 000 years, is compatible with the ejecta of deep sedimentary layers. In a natural formation, the surface layers would be younger.

5.2. Historical arguments

World War II ushered in the practice of massive aerial bombardments. When, due to counter-orders, weather (fog, clouds) or damage (enemy anti-aircraft defence), the planes were forced to return to their base without being able to complete their mission, it was either too dangerous for them to land with their bomb load, or the weight of the bombs would have increased their fuel consumption too much. It was therefore the rule, before landing at the departure airfield, to jettison unused bombs at sea, possibly quite close to the coast. The areas dedicated to this operation are referred to as 'jettison zones' (Wikipedia Contributors, 2023).

Numerous testimonies from World War II pilots show that these bomb dumps, following aborted missions, were very frequent (Granfield, 2011; Griggs, 2015). For example, on December 15, 1944, a single raid aborted due to fog led a squadron of 138 RAF Lancaster bombers to drop around 100 000 incendiary projectiles and nearly two hundred 'Cookies' (giant 1.8 metric ton bombs) in the English Channel (Wikipedia Contributors, 2023).

On October 4, 1943, Corsica was itself liberated from the Italian and then German occupation, thanks to an uprising by the local population, Corsican *maquisards,* the landing of Free French Forces (the emblematic submarine *Casabianca*), as well as a change of heart among the Italian soldiers facing the Germans (Gambiez, 1973; Ferranti, 2013; Gregori, 2023).

The US army landed in Corsica in December 1943 and built 17 airfields for its hundreds of bombers and went so far as to give the name of an aircraft carrier to the island: the 'USS Corsica' (**Fig. 3a**) (Taddei, 2023). More than 2 000 bombers, fighters and reconnaissance planes from the USAAF (United States Army Air Forces), the RAF (Royal Air Force) and the French Air Force were thus positioned on the island. The main types of bombers used were the B17 Flying Fortress, B24 Liberators, B25 Mitchells, and B26 Marauders (**Fig. 3b-e**).

The famous French writer, poet, journalist and aviator Antoine de Saint-Exupery performed reconnaissance missions, from the Bastia-Puretta airfield (Corsica), to collect intelligence on German troop movements, in preparation for the Allied invasion of southern France. He disappeared while on one such reconnaissance mission, on July 31, 1944. The wreckage of his plane, a P38 Lightning, was discovered off the coast of Marseilles in 2000 (Vaudoit *et al.,* 2004; Pradel and Vanrell, 2008).

Each bomber pilot had to carry out at least 70 raids before being replaced. Until April 1945, several thousand raids were carried out on northern Italy and southern France. A strategic target was the Brenner Pass over which runs the railway line connecting Austria to Italy (Verona and Innsbruck are on this line), a line that was used to supply the German armies (**Fig. 3f**). From November 6, 1944, to April 25, 1945, the 57th Squadron of B25 Mitchells conducted 6 839 raids, lost 46 aircraft, and had 532 aircraft damaged (57th Bomb Wing Association, 2018; 57th Bombardment Wing, Twelfth Air Force, 2018).

Other important raids on Italy and southern France were carried out from Corsican airfields such as the bombing of Monte Cassino on February 15, 1944 (United States. Dept. of the Army, Office of Military History, 1947), of Nice and Saint-Laurent-du-Var on May 26, 1944. Corsica was also on the route of massive raids such as the one on Marseille on May 27, 1944, carried out from Brindisi. (Wikipedia Contributors, 2024).

During all bombing raids, human and material losses were enormous, and many bombers returned damaged and unable to carry out their mission. There are numerous testimonies of pilots forced to jettison their bombs at sea before returning to Corsica (Shepherd, 1996; Taddei, 2003; Shores *et al.,* 2018). These operations to offload unused and generally unprimed munitions required the designation of jettison zones off the Corsican coast, and the two coralligenous atoll areas discovered north of Cap Corse are situated where one would expect them to be found: on the return route from raids on southern France and northern Italy (notably those on the Brenner Pass, **Fig. 3f**).

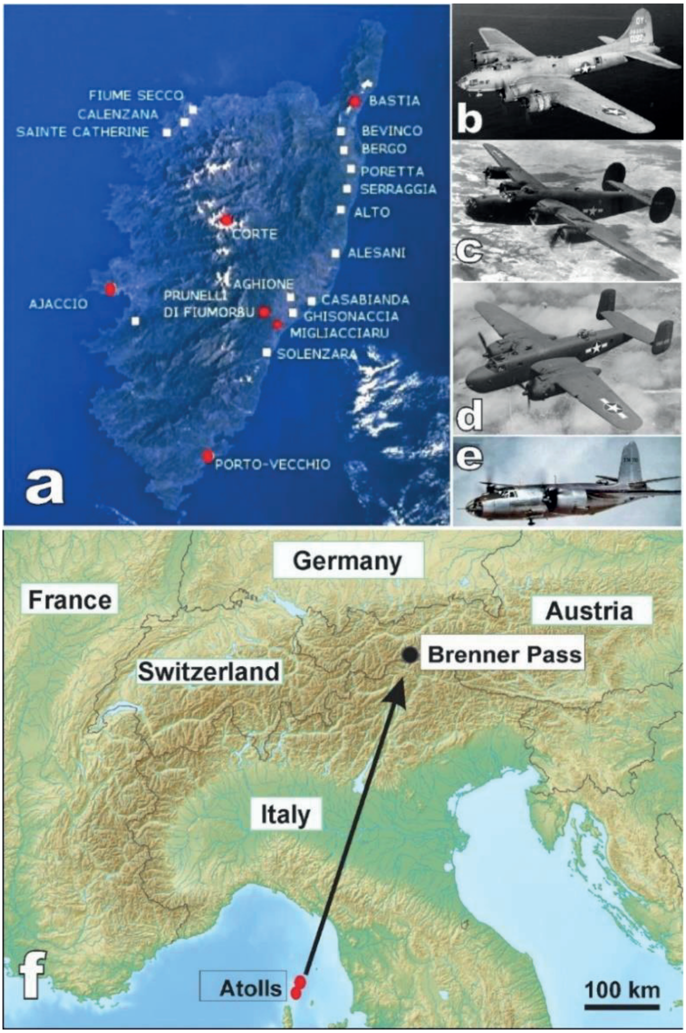

Figure 3. Corsica, playing the role of a giant Allied aircraft carrier during the Second World War. **a**: location of US military airfields in 1944 in Corsica (from Marcel, 2024). **b**: B17 Flying Fortress. **c**: B24 Liberator. **d**: B25 Mitchell. **e**: B26 Marauder (**b-e**: from Wikimedia commons). **f**: Location of the Brenner Pass and of the coralligenous atolls off Cap Corse, on the route of the Allied bomber squadrons (drawing © Marc Verlaque).

In the Baltic Sea where large quantities of conventional ammunition were dumped at the end and after World War II, many explosion craters were identified on the seabed (Kampmeier et al., 2020; Papenmeier *et al.*, 2022; Díaz-Mendoza *et al.*, 2023) (**Fig. 4a**). In the *Posidonia oceanica* meadow of the east coast of Corsica, north of the Sulinzara airfield (between Sulinzara and U Cateraghju), approximatively north-south alignments of circular spots of dead matte have been observed (**Fig. 4b**) (Clabaut *et al.,* 2014). They may correspond to the Sulinzara (as Solenzara, **Fig. 3a**) jettison zone. Bomb impacts from World War II have also been described in *P. oceanica* meadows of Provence and French Riviera (Meinesz and Lefevre, 1984; Pergent-Martini, 1994; Pergent-Martini and Pergent, 1996; Pergent-Martini and Pasqualini, 2000) and Corsica (Clabaud *et al.,* 2014).

On the seabed of the Grande Rade of Toulon (France), Garlan *et al.* (2018) reported 661 high backscatter circular structures, with diameters ranging from 11 to 134 m, and very specific characteristics, which clearly differentiate them from other sedimentary, biological and geological figures encountered on the seabed (**Fig. 4c and 4d).**

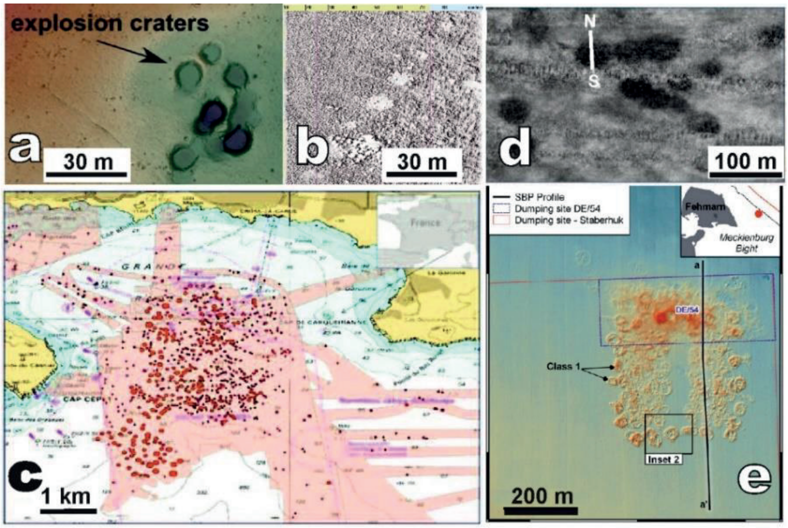

Figure 4. a: explosion craters of around 25 m diameter in a post-war marine munition dumpsite (Baltic Sea; from Kampmeier *et al.,* 2020, modified). **b:** line of possible bomb impacts in the *Posidonia oceanica* meadow (East coast of Corsica, north of the Sulinzara airfield; courtesy of Gérard Pergent). **c-d:** circular seabed structures observed on multibeam echosounder images of the Grande Rade of Toulon, France (in red on the map; diameter: 11 to 134 m) (Source: Garlan et al. (2018). Reproduced and modified with permission from the Coastal Education and Research Foundation, Inc.). **e:** bathymetry images of a dumping areas. Insets show the typical torus shape of the structures of Class 1 (Southwestern Baltic Sea; from Diaz-Mendoza *et al.,* 2023, modified).

These circular structures are usually clearly separated but can sometimes partially overlap. They seem to be randomly arranged in terms of distribution and size, but sometimes they are arranged in a line; they are in this case series of circles with similar diameters and sharpness of outline. These sedimentary structures indicate that they have been generated by the explosion of bombs. The oldest ones most probably result from bombs dropped in 1940, and 1944 during the landing of the Allied forces.

In the Baltic Sea, Díaz-Mendoza *et al*. (2023) identified more than 3 000 circular seabed features (diameters between 6 and 77 m) corresponding to pockmarks, dumping spots and explosion craters (**Fig. 4e**). These authors propose a classification into six classes, which provides an overview of their formation mechanisms (**Table 1**). Coralligenous atolls correspond well to classes 1, 2 and 3, which all have an anthropogenic origin (i.e. detonation craters, bomb droppings and dumping of dredged materials). Like in Corsica, the circular elements of class 1 are often grouped, sometimes merged with edges of varying height and width, and often with a central elevation.

Table I. Classification of circular seabed structures and schematic representation showing main features classes observed in the hydroacoustic data (Southwestern Baltic Sea; from Diaz-Mendoza *et al.,* 2023).

	Class	Description	Feature name / suspected origin	MBES /SSS Backscatter	SBP Profile
Anthropogenic features	1	Positive relief, ring-shaped features with high backscatter and in SBP internal chaotic reflectors. They are above mean seafloor depth and very often present internal elevations.	Dumping rings / Dumping of dredged material		
Anthropogenic features	2	Random high backscatter 'splotches', positive relief or slightly negative relief (depending on the hardness of the substrate).	Random dumping spots / Dumping of material		
Anthropogenic features	3	Flat areas of string of high backscatter rounded spots with no evidence of seismic acoustic anomalies.	Strings of dumping spots / Loss of dumping material		
Anthropogenic features	5	U-shaped craters without elevated rims.	Craters / ammunitions blasting		
Natural features	6	Craters without elevated rims and with gas related acoustic anomalies: acoustic turbidity, acoustic blanking, high-amplitude reflectors.	Pockmarks / Seepage activity		
Ambiguous	4	High backscatter ring-shaped features with elevated rims and vertical seismic acoustic anomalies, enhanced reflectors, velocity 'pull-up' reflectors, and in association with acoustic blanking.	No defined		

Backscatter intensity: High – Low

Acoustic anomalies

6. Conclusion

The various surveys carried out on the coralligenous atoll fields of Cap Corse have not yet collected any convincing geological, hydrodynamic, biological, or current-driven elements to support the hypothesis of a natural and ancient origin.

During the most recent oceanographic survey (*Gombessa 6 Cap Corse*), the participants themselves once again highlighted the main feature that is difficult to reconcile with a natural origin: the very constant and very regular size of the atolls.

In contrast, the arguments, both structural and historical, in favour of a recent and anthropogenic origin of the coralligenous atolls, the jettisoning of unused and unprimed bombs during World War II, are numerous. It is a historical fact that, during this conflict, jettison zones were used around Corsica, and the possibility that the two fields of coralligenous atolls discovered off the coast of Cap Corse are the first two jettison zones to be located around the island deserves consideration. The data, particularly magnetometry data, collected during *Gombessa 6*, still being analyzed, will perhaps make it possible to confirm this hypothesis. If this were the case, it would be desirable, for security reasons, to seek to locate other possible jettison zones around Corsica.

Due to the originality of these formations, their high specific diversity, and a supposed ancient and natural origin, these atolls were considered, soon after being discovered, as natural monuments of high heritage value. Strong protection measures were therefore considered (e.g. ban on anchoring). One accident has already taken place in October 2018 with the collision between the ro-ro ferry *Ulysse* and the containership *CSL Virginia,* anchored 28 km north-west of the Cap Corse (Boudouresque *et al.,* 2019).

If their recent and anthropogenic origin were confirmed, would these potential protective measures become irrelevant? The answer is clearly no. Whatever the origin of the atolls, their large number and their raised structures (domes and crowns) on a sub-horizontal coastal detrital bottom create environmental conditions particularly favourable to the development of a coralligenous bank (*coralligène de plateau*) and the installation of a species-rich benthic flora and fauna, with high heritage value and high conservation priority (**Fig. 5**).

Even if their origin is not natural, these lush coralligenous formations deserve to be preserved. Furthermore, like other vestiges of World War II, such as the conning tower of the *Casabianca* submarine in Bastia (a replica of which is visible at Place Saint Nicolas) (Griffi and Preziosi, 1988; Wikipedia contributors, 2023) and the wreck of a B17 Flying Fortress in Calvi, 26 m depth (Barraqué *et al.,* 2009), the memorial aspect must also be considered.

Finally, independently of a concern for heritage conservation, if the hypothesis of a jettison zone is confirmed, a limitation of human activities (anchoring, trawling, drilling, dredging, installation of wind turbines and burying of submarine cables) should also be strongly recommended for safety reasons. Unexploded bomb dump areas are theoretically closed to navigation. For example, in the Channel/North Sea zone, there are at least three zones of this type: one near the English coast, one in the Thames estuary and the third in the Pas-de-Calais (Contributors to Wikipedia, 2023).

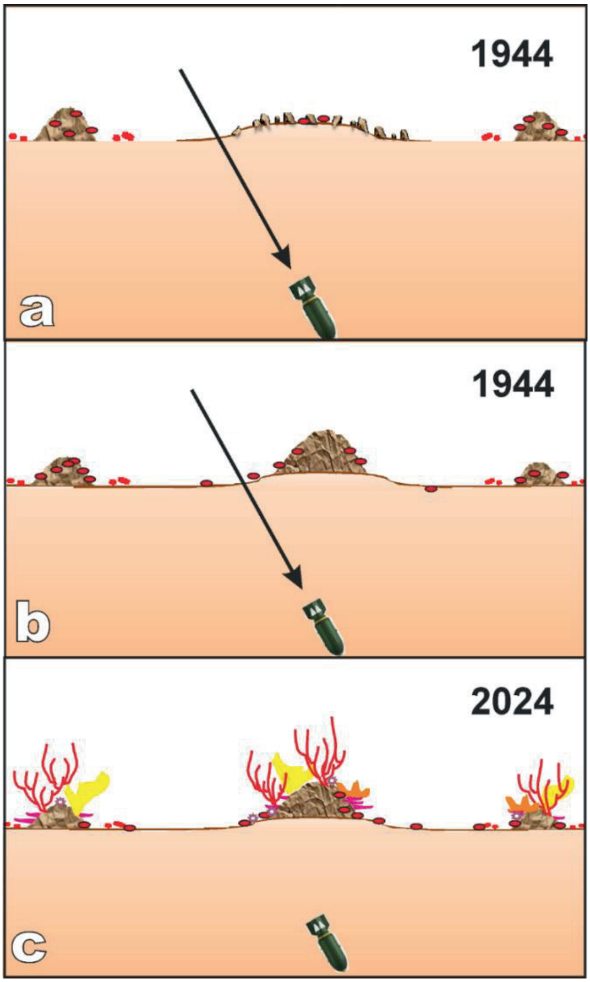

Figure 5. The recent and anthropogenic hypothesis of the formation of coralligenous atolls. **a-b**: diagrams of the formation of atolls with variable central dome in 1944. **c:** diagram of a coralligenous atoll with its rich benthic flora and fauna in 2024. (drawing © Marc Verlaque).

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