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BIOGENIC CONSTRUCTIONS IN THE MEDITERRANEAN

A REVIEW

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BIOGENIC CONSTRUCTIONS

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Jacques LABOREL
Professor
University of AIX-MARSEILLES II
and
Centre d'Oceanologie de Marseille

Box 901
13288 MARSEILLE Cedex 9

FOREWORD

It is a widely overlooked fact that the Mediterranean sea is rich in biogenic buildings of various types. Although the latter may be less conspicuous than those of tropical seas, they are neverthless important and urgently need a general survey in order

1) to **protect** them against pollution and decay of all kinds
2) **to make good use** of their esthaetic properties as attractive features for surface and underwater touristic activities.

WHAT IS A BIOGENIC STRUCTURE ?

Many marine plants and animals have a solid (generally calcareous) skeleton by which they stick to the substrate and which perdures at the same place after the death of the organisms. In some cases, provided the growth of the organisms is sufficiently rapid and they are sufficiently crowded, the accumulation of limy remains may lead to a kind of permanent rocky structure of caracteristic pattern and variable size the upper surface of which only is living over an accumulation of dead parts.

These features, the most representative of which are the tropical **coral reefs**, and which are known under the general denomination of **biogenic buildings** may grow for centuries and reach important size; in some cases they may still be seen as a fossils centuries or millenia after their death.

Some biogenic buildings are too small or too inconspicuous to be of else than scientific interest, but, in many parts of the Mediterranean, examples of such buildings are known which, by their size, form and colors, may be extremely attractive and conspicuous to the surface or underwater observer.

In the Mediterranean, current biological and geological research during the last thirty years has discovered more than a score of various types of biogenic buildings, growing at various depths and in different types of places or biota.

I shall present them briefly, taking into account their vertical and horizontal location, the degree to which they have been surveyed in the various parts of the Mediterranean, their potential attractiveness as natural momuments and the various dangers that are threatening them.

DESCRIPTION AND RANGE OF VARIOUS TYPES

Two important factors must be taken into account when dealing about biogenic structures : these are the depth at which the structure is growing and the nature of its biological components. In the Mediterranean area, seven different types at least of biogenic buildings may be found which are, according to the depth at which they develop.

a) surface and subsurface buildings

1) The *Lithophyllum lichenoides* rim
2) The algal-vermetid rim and its various types
3) The *Corallina* rim
4) The *Lithophyllum incrustans* rim

b) underwater buildings

5) Serpulid rims and reefs
6) The *Cladocora* banks
7) The "coralligenous" algal banks

The depth in itself is not a dominant factor : more important is the **place in the benthic zonation** as defined by marine biologists (and notably by PERES & PICARD whose zonation scheme is now considered as a standard in the Mediterranean for the bulk of marine scientists working in that area).

Following the definitions of these authors we shall consider biogenic buildings growing in the following zones, from the surface to the edge of the littoral shelf.

midlittoral zone buildings represented only by **(1)**
upper infralittoral zone buildings : **(2), (3), (4), (5)**
lower infralittoral zone buildings : **(6), (7)**
circalittoral zone buildings : **(7)**

The following figure (Fig. 1) gives an idea of the vertical range of these buildings in ther Mediterranean.

1) The *Lithophyllum lichenoides* rim :

This is a well known feature in the western Mediterranean basin, its structure has been extensively studied in the last thirty years (PICARD,1954, BLANC & MOLINIER 1955 and others), it has been referred to as "trottoir à *Tenarea*", "trottoir à *Lithothamnion*", or "trottoir à *Lithophyllum tortuosum*" by the authors who studied it from a biological, geological or archaeological point of wiew.

Zonation

This is the highest biogenic building in the Mediteranean, it is always found a little over the main sea level, in the so called *midlittoral zone* (or surf zone). This means that when the sea is calm in the more or less tideless western Mediterranean basin, it stands almost completely out of water.

The rim is limited to places where the exposure to surf is strong, but not exceeding an upper limit. It is generally best developped on coasts exposed to prevailing winds, in coves, fends or crannies open to the surf. Since the dominant factor is the mean wave energy on a year-round scale, the actual height of the rim above sea level is variable : in places of strong exposure it is generally higher and thicker than in calmer localities.

Biological agent

From a biological point of wiew, the rim is monospecific and entirely made of the calcified thalli of a red alga *Lithophyllum lichenoides* . (*Rhodophyta, Corallinaceae*)

Structure

The morphology of the rim is highly variable (from a simple coating to a wide steplike rim) and it is able to develop to its full extent in a limited number of cases only. In the latter case it may consist of a wide cornice with a flat or slightly depressed surface, up to two metres wide, ending in a salient rim with a vertical face.

In some cases two facing cornices may coalesce and bridge over a fend in the rock or even over a small embayment.

The inner structure is relatively complex (Figure 2) and shows at least three different layers : an outer layer (1), made of the living thalli of the coralline alga, this layer is only some inches deep and limited to the upper surface and outer face of the rim. Under the living layer a hardened zone (2) of variable thickness is to be found, which is the result of complex biological (vertical growth) and geological (diagenesis, cementation) phenomenons. This hard layer is very often multi-layered, a structure which has not been completely explained (LABOREL *et al.*, 1983).

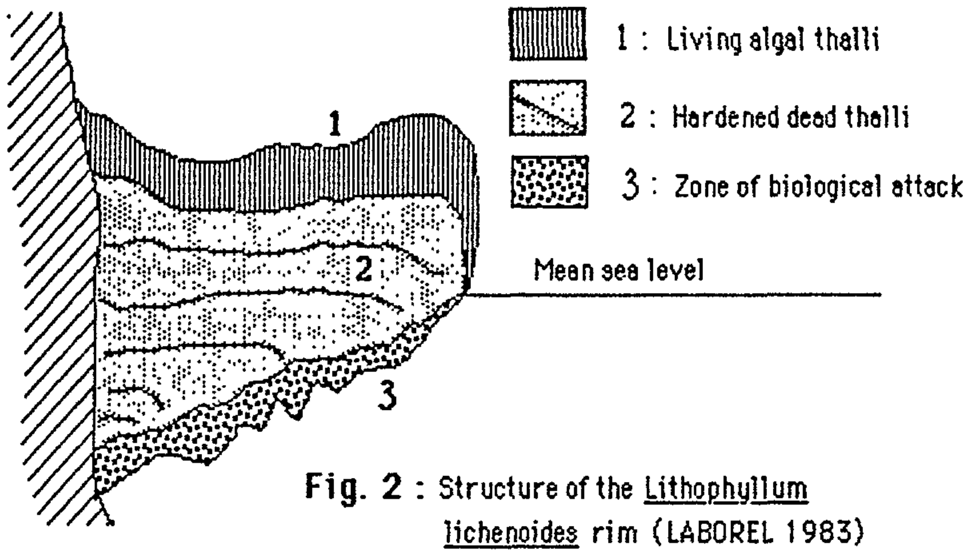


Fig. 2 : Structure of the Lithophyllum lichenoides rim (LABOREL 1983)

The lower surface of the rim is always dead and more or less covered by shade loving (sciaphilous) assemblages of algae and invertebrates, including various rock boring species such as Clionid sponges and boring mussels the action of which results in a more or lesss intense biological erosion (3).

The relative thickness of the latter three zones is variable according to the place, wave energy and geological history of the littoral where it develops.

Geographical range

The *Lithophyllum lichenoides* rim is a common feature of the coasts in the western mediterranean basin (although the alga may be found in many places out of that area, including Portugal and the coasts of the Gulf of Biscay) but seems to be absent from the eastern mediterranean basin where many previous descriptions of "trottoir à *Lithophyllum*" are due to confusing with vermetid-algal rims or with erosional benches. Well developed rims are known from coasts of Spain, littoral France (Marseilles, coast of Var and Alpes maritimes including the islands of Port Cros, Porquerolles, Le Levant and Corsica), Sardinia, western Italy and Sicily, and North Africa. A detailed survey is yet to be made but few very important "trottoirs" (exceeding a width of one metre) are known, except in the island of Porquerolles at "Le grand Langoustier" (PICARD 1954) and on the western coast of Corsica , south of Calvi, at Punta Palazzu (C.F. BOUDOURESQUE pers. comm.).

2) The algal-vermetid platform and its variants :

First discovered in Sicily in 1854 by the french biologist Henry de QUATREFAGES, these formations were later described by PERES &PICARD (1952), BLANC & MOLINIER

(1955), and then compared with tropical reef formations by KEMPF & LABOREL (1968) and SAFRIEL (1974)

Biological agents

The platform is partly built by the close association of two species : a Vermetid Gastropod, *Dendropoma (Novastoa) petraeum* (Monterosato) often referred in biological papers as *Vermetus cristatus*, and a coralline Alga : *Neogoniolithon notarisi* (Dufour) Setchell & Mason.

These two species are completed by a number of epiphytic and endolithic species among which the sessile Foraminifer *Miniacina miniacea* plays an important part as a cavity filler. The relative proportions of the two main components are highly variable, following the degree of exposure to surf. In conditions of high energy, Vermetids are abundant whereas they disappear in very low energy situations. In the latter case pure *Neogoniolithon* formations are found, as it is the case in the sheltered hypersaline waters of Bahiret el Bibane, in Tunisia (THORNTON *et al.* 1978, DENIZOT *et al.* 1981).

Zonation

The vermetid-algal formation are always more or less dry at low tide or in very calm weather, but always at a lower level than the *Lithophyllum lichenoides* rim.

This may be seen clearly whenever the two types of formations coexist (in Corsica for example), the thalli of *Lithophyllum* growing at the summit of the Vermetid rim or slightly higher. From a biologist point of view, the upper surface of the Vermetid-algal rim marks the upper limit of the infralittoral zone and may be considered as a <u>remarkable biological marker of mean sea level.</u> (FEVRET & SANLAVILLE 1966) the interest of which for tracing ancient shorelines will be emphasised in a later paragraph.

Structure

The morphology is highly variable and three types at least are currently met with.

a) <u>the bench or platform type,</u> which is is more or less wide platform, extending at sea level and covered by shallow pools, a few centimetres deep. Observation of the platform shows that it is not build-up by marine organisms but that it is an **erosion form** cut into the rock itself(often a sandstone, soft limestone or shales). At the edge of the platform lies the biogenic structure itself, under the form of a more or less thick rim, the surface of which is left dry in calm waters. The latter may be a complex structure,supported by short pillars ans enclosing small cavities.The upper surface and sides are often covered by brown algae, mostly *Cystoseira*. This is the commonest form in Corsica , Spain,Sicily and North Africa (MOLINIER & PICARD 1954a,b)(Fig. 3)

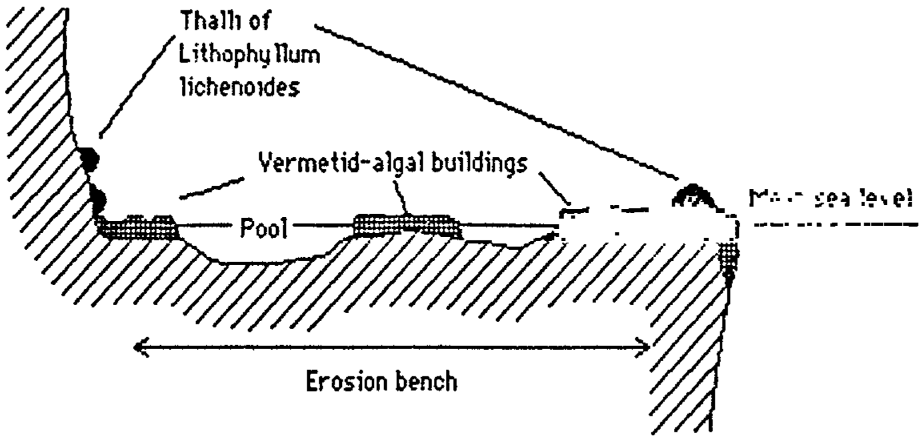


Fig. 3 : Vermetid-algal rim : from BLANC & MOLINIER 1955

b) <u>the "atoll" type</u>, is a common form in the eastern mediterranean basin, notably in Crete (KELLETAT 1979) and Israel (SAFRIEL 1974) . In that type, a complex combination of constructive and erosive forces lead to the formation of an annular structure with a constructed rim and hollowed "lagoon", which is very near the famous "boilers" of the Bermuda islands (KEMPF & LABOREL 1968, ,SAFRIEL, 1974).(Figure 4)

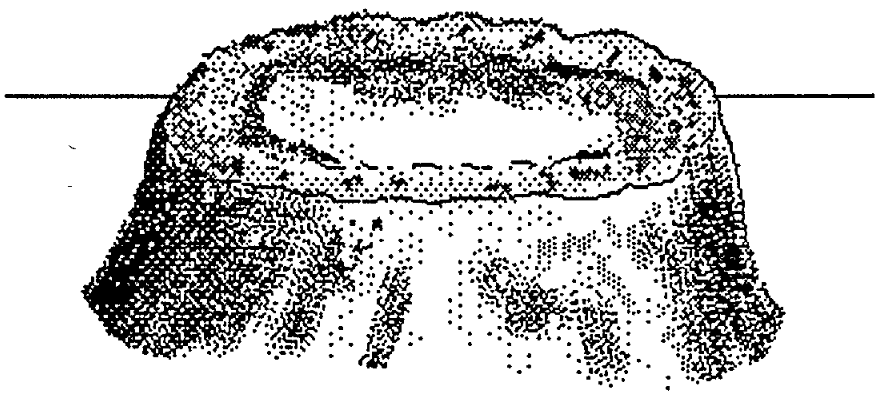


Fig. 4 : Vermetid-algal "atoll" on the coasts of Israël and northern Crete From SAFRIEL (1974) and KELLETAT (1979)

c) <u>the "cornice" type</u>, was described from Corsica by Roger MOLINIER (1955a and b, 1960). It is the simplest form of all, a mere horizontal bourrelet running along a vertical cliff, looking very much like à *Lithophyllum lichenoides* cornice. In the latter case the basement is a hard volcanic or crystalline rock and erosive forces are not at work.

The inner structure is a very characteristic one and is dominated by the brown coiled tubes of the Vermetid gastropod and the chalky white compact thalli of *Neogoniolithon*, with occasional pink "flakes" of *Miniacina* : it is generally impossible to make any mistake with other types of biological buildings.

In very rare occasions were mixed structures observed with superposed layers of *Lithophyllum* and *Dendropoma* : these all were fossil forms and corresponded to a sudden change in sea level (THOMMERET *et al.* 198)

Geographical range

The Vermetid-algal formation is a typical warm water component of the mediterranean landscape. Its fauna and flora show a high proportion of tropical genus and the biogenic formation itself is very near the "algal ridge" of tropical coral reefs. According to these tropical features, vermetid algal formations are found in the warmest parts of the Mediterranean, excluding the continental coasts of the Gulf of Lion (Northern coast of Spain, french continental coasts, northern coasts of Italy at least down to the latitude of Roma. On the corsican coasts, its distribution is patchy and the cornices are always small owing to a mixture of cold and warm influences. Best developed formations are known from Sicily, Tunisia (MOLINIER & PICARD 1953, 1954), and the whole eastern basin (notably Crete, Lebanon and Israel)(KELLETAT 1979, FEVRET & SANLAVILLE 1966, SAFRIEL 1974).

3) The *Corallina* rim

Discovered in Corsica by Roger MOLINIER (1955), this interesting and often spectacular building has never yet been surveyed in the Mediterranean and may have been overlooked in many places despite its interest.

Biological agent

As implied by its name the *Corallina* rim is built by the basal layers of an otherwise erect and articulate coralline Alga : *Corallina elongata*. Other algal and animal components may also be met with such as *Lithothamnium lenormandi* and *Miniacina miniacea*.

Zonation

The *Corallina* rim is not so strictly linked to the surface as the two preceding types of biogenic buildings and it may be found from just under sea level down to several metres deep. It is a shade loving formation, occuring on vertical or overhanging cliffs, in relatively shaded places : mostly crevices and narrow littoral embayments.

Structure

The morphology is relatively simple : in many cases the *Corallina* formations are set as a series of horizontal ridges of variable length parallel to an overlaying cornice of *Lithophyllum lichenoides*(Figure 5). But the rims may be so short as to be more or less spheroidal fist size formations.

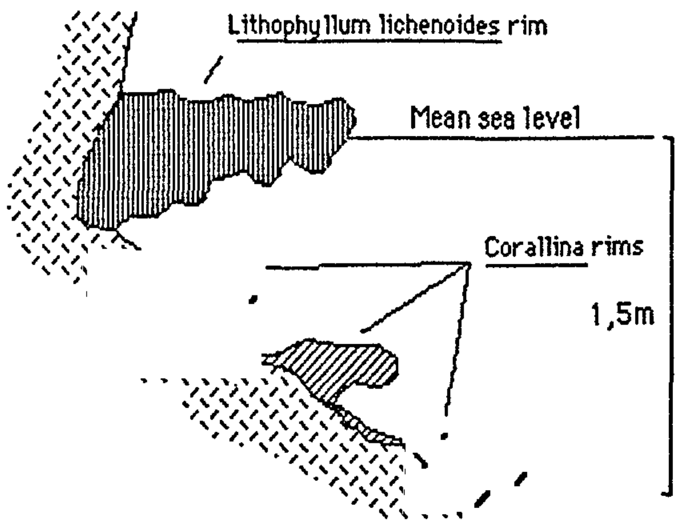


Figure 5 : Corallina rims, Porticciolo, Corsica From BLANC & MOLINIER (1955).

The inner structure is generally simple and compact : a hard laminated structure with numerous pink skeletons of *Miniacina*, some barnacles, Bryozoa and so on. But its main interest is that a living *Corallina* rim may often conceal (and protect from erosion) a fossil core of *Lithophyllum lichenoides*, marking an ancient sea level (LABOREL *et al* 1983) hence the great archeological interest of that litle known and often overlooked formation.

Geographical range

In the absence of a general survey at the Méditerranean scale the range of *Corallina* rims is presently limited to Corsica and the continental coasts of France. But there is a high probability that it might be wider in western and maybe eastern mediterranean basins.

4) The *Lithophyllum incrustans* rim

A little known and generally poorly developed formation of minor importance, it must be quoted altogether since, as the latter type it may conceal a core of fossil *Lithophyllum lichenoides* rim.

Biological agent

Lithophyllum incrustans is a pale purplish brown coralline alga which may develop in pools or on rocky surfaces. The thalli are often coalescent and build small size constructions in many places including outside the mediterranean area.

Zonation

At the upper part of the infralittoral zone and down to several metres deep, mostly under shady overhangs.

Structure

There is no typical growth form for that small zized type of building : thick corniced formations have been described by MOLINIER,(Fig. 6) but in many cases small fist-sized growth forms have been observed in well lit conditions. The alga makes the bulk of the calcareous mass but other species such as the vermetid *Vermetus triqueter* and barnacles are also present.

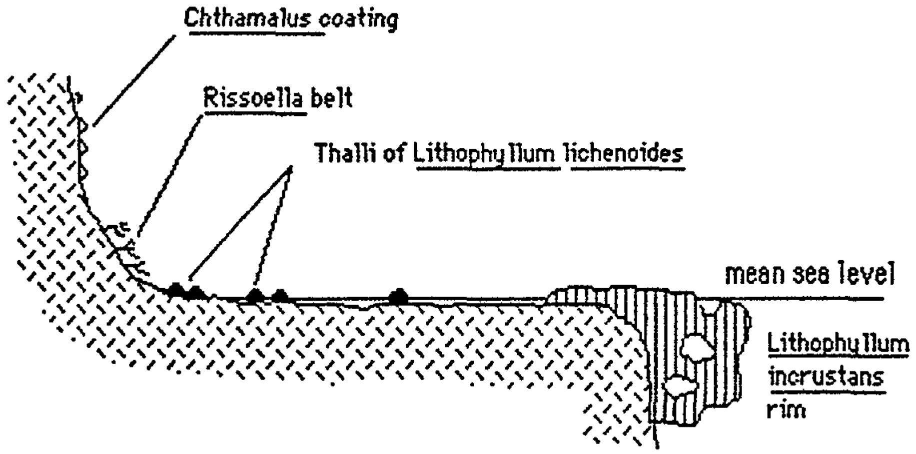


Figure 6 : Rim of Lithophyllum incrustans
Farinole, northern Corsica.
from BLANC & MOLINIER (1955).

Geographical range

The typical place of description (MOLINIER 1955) is the North of Corsica, but smaller, still undescribed forms of that type have been observed in Port Cros National Park and other places in the western mediterranean basin.

5) Infralittoral Serpulid reefs

These are very poorly known, with only fragmentary descriptions in the biological litterature. Some of them may even have been confused with vermetid formations At least two different types have been described : euryhaline serpulid rims from open sea conditions and polyhaline "reefs" of hypersaline lagoons.

Biological agent

Several serpulid species are said to take part in the buildings of the "balcons de Serpulidés divers" (PERES & PICARD 1952). As for the hypersaline reefs, those of the Tunis lagoon are made by the serpulid *Mercierella enigmatica* (HELDT 1944).

Zonation

All serpulid formations are comprised between the surface and 15 metres deep.

Structure

The structure and morphology are very diverse : open water types seem to build unstable and poorly cemented cornices in very calm and sheltered situations, the *Mercierella* reefs, on the contrary are able to build large atoll-like structures several tens of metres wide, but easily destroyed by waves or by biological erosion.

Geographical range

Open water forms were described from western Corsica (Ile Rousse) and Marseilles,but no survey or recent work on these apparently rare and unstable formations was made since their initial description; lagoon forms are known from the lake of Tunis.and other mediterranean lagoons.

6) The *Cladocora* banks

This is an extremely interesting formation since it is the only one in the Mediterranean to be built by a true reef coral (hermatypic Scleractinian coral) and to besimilar to true coral reefs of the tropical seas.

Biological agent

The Scleractinian *Cladocora caespitosa* Linneus is a bushy coral, made of many parallel branches, each with one calice at the tip. The tissues of the polyps are brown and loaded with numerous Zooxanthellae. Since *Cladocora* possesses both principal characters of hermatypic corals : zooxanthellae and the possibility of building reefs, it may be classified as such without hesitation.

Cladocora caespitosa is an endemic mediterranean species tolerating relatively low winter temperatures, but a very near related species *Cladocora arbuscula* is a caribbean endemic which grows in similar conditions and may also take part in reef building processes.

Zonation

It is comparable with that of true reef corals in tropical seas : *Cladocora* may grow from just under the surface to some 25 metres depth. Thus the *Cladocora* banks belong to the infralittoral zone of marine biologists.

Structure

The morphology is extremely simple : big irregular masses, built by coral branches and which may fuse into large banks, several hundred metres wide.

The surface of the bank is covered by the living polyps of the coral and also by numerous epiphytic species, such as green algae *Halimeda tuna* , *Udotea petiolata* and Sponges.

Geographical range

Presently, *Cladocora* banks are known from, one part of the Mediterranean only, the gulf of Atalanti (Evboikos Kolpos) and the straits between Eubea island and the continental mainland. Isolated banks may be present in many places in the Egean but no survey other than a quick one has ever been made of these very original formations. In Tunisia, important dead banks of *Cladocora* are known which are now covered by siltation. In Corsica, dead coral masses of several metres diameter have been recently observed by us, which are covered and preserved from erosion by a thick incrustation of calcareous algae. ^{14}C dating of these formation gave results ranging from 600 to 2400 years BP. As a matter of fact it appears that the present range of *Cladocora* in the Mediterranean may have shrunk recently compared with its fossil distribution. Ancient wrecks have been found resting on a pavement of silted coral colonies in places where the species is now only represented by scarce small-sized colonies.

The reasons of this impoverishment are not known but may be linked with climatic or ecologic changes. It would be all the more interesting to make a complete survey of the phenomenon since *Cladocora* is now a menaced species, both sensitive to pollution and extensively collected by divers.

7) "Coralligenous" algal banks

First described and named by the french biologist MARION in the last years of the XIXth century, these biogenic formations have been mostly studied by french and italian biologists, and are often overlooked or underestimated by english-speaking scientists.

The word "coralligenous" although widely used (and notably by PERES *in* O. KINNE 1982) is certainly an awkward one, since it gives the false impression to refer to coral reefs and reef-building Scleractinian corals. This name was eventually given by MARION to calcareous algal formations in the cavities of which the precious red coral *Corallium rubrum* is often found growing. The term of "coralligenous" algal banks seems to give a better account of these particular mediterranean formations.

Biological agents

"Coralligenous" algal banks are built by a relatively great number of species, among which the following few are important (HONG 1980) :

Mesophyllum lichenoides (Ellis) Lemoine
Pseudolithophyllum expansum (Philippi) Lemoine
Pseudolithophyllum cabiochae Boudouresque & Verlaque
Neogoniolithon mamillosum (Hauck) Setchell & Mason
Peyssonellia rosa marina Boudouresque & Denizot

Several other calcareous algae occur, which also belong to the families *Corallinaceae* and *Peyssonelliaceae*.

The banks themselves, which may be several metres thick, are slowly built by the algal thalli overgrowing one another. Animals play also a noticeable part in the building of the "coralligenous" banks : most important are the Foraminifer *Miniacina miniacea* along with many species of Bryozoa, some scleractinian corals, the precious red coral *Corallium rubrum*, and Serpulids. All these animal components live in the shade of the overhangs and crevices which are so characteristic of these banks. Many non-building algal and animal species (notably Sponges, Gorgonian corals , Annelids, Crustacea and so on) also occur in that remarkably rich biotope.

Zonation

"Coralligenous " banks have been at first described (PICARD 1954, LABOREL 1961, PERES & PICARD 1964)as exclusively belonging to the so called circalittoral zone . In the Mediterranean sea, such a place in zonation means that "coralligenous" banks should always occur clearly below the lower limit of the *Posidonia* meadows.

Recent investigations (SARA 1967-1969, HONG 1980) have shown however that such formations could also occcur in significantly shallower waters, and especially among the rhizomes of *Posidonia* which can be sometimes completely covered and smothered by the development of *Mesophyllum lichenoides*, which is the more light loving (photophilous) species among the bank-building coralline algae.

The actual depth at which algal banks may be found is extremely variable and depends upon the transparency of the waters and the influence of submarine topography (Figure 7). On flat bottoms one can find them from 12-15 metres (Gulf of Fos, HONG 1980, Pugliese coast of italy, SARA 1967-69) to more than 120 metres in the Egean sea (PERES & PICARD 1964). On vertical cliffs and in the outer part of submarine caves, algal formations build horizontal lips or rims, set up at regular intervals. Theses lips may grow to extreme size and be more than three metres wide.

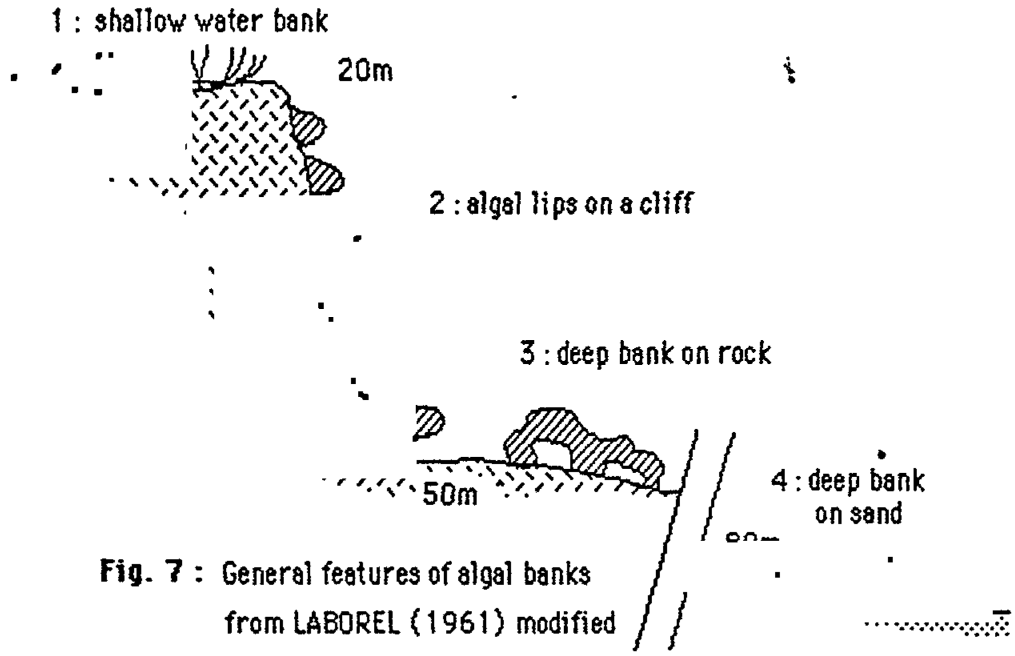


Fig. 7 : General features of algal banks from LABOREL (1961) modified

Structure

The morphology is variable depending upon depth, topography and the nature of the prevailing building species.

a) banks : Shallow water *Mesophyllum lichenoides*-built banks are generally flat or slightly rounded, with a light, foliaceous structure.

As the water deepens , the relative proportion of *Mesophyllum lichenoides* decreases and other algae develop. Banks are generally flattened structures with a thickness ranging from half a metre to 3 or even four metres when well developed. They are generally very cavernous, beeing excavated by boring organisms in all shaded places which are not coated by calcareous algae. These excavated parts generally bear shade-loving faunistical assemblages in which sponges and the precious red coral *Corallium rubrum* are common components. The great development of cavities often leads to a very curious morphology of "undermined" banks, born by residual pillars.

Shallow water banks are generally covered with green algae *Halimeda tuna* and *Udotea petiolata*, which hide more or less completely the calcareous algae but, as the water deepens, the former species disappear and the surface-covering corallines appear. Figure 8 shows a typical bank in the relatively muddy waters of the south western shores of continental France in Banyuls (Pyrénées orientales), near the spanish border. Similar banks are found at greater depths when the water is clear, 40 to 70 metres generally. In eastern mediterranean, the lush growth of calcareous algae often presents the diver with spectacular landscapes, in which the algal thalli *look like beautiful rosettes of precious pink china*.

The structure of very deep banks (lower than 70 metres) is poorly known. Since they are often surrounded by sandy bottoms, they were said to have developed from the fusing and coalescence of free rolling algal thalli or rhodolithes ("coralligène de plateau" of french authors) at the difference of shallower formations which normally grow on top of rock surfaces. Further studies are neverthless necessary since it appears highly probable that many such deep banks also develop upon rock outcroppings.

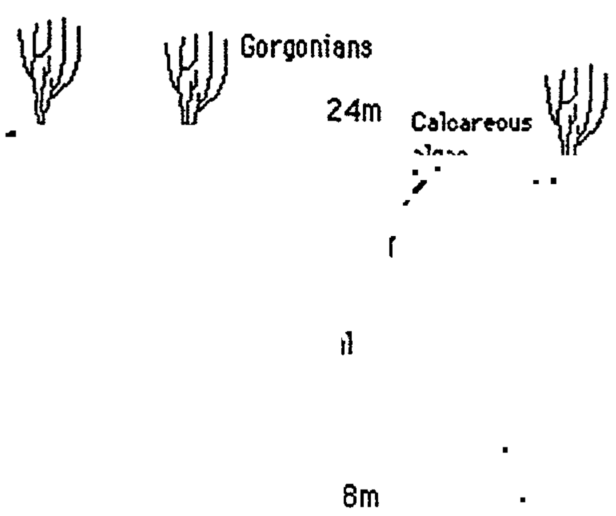


Fig. 8 : Cut through an algal bank near Banyuls (France)

b) Lips and rims : *They are found in the outer part of marine caves and on* vertical cliff faces and show a striking parallelism one to another. It seems that the regular periodic pattern of subequal horizontal rims of increasing width is produced by the growth of algal thalli in form of bracket-like horizontal colonies, bringing shade to the underlying surfaces, hence inhibiting algal development on the latter.

The regular widening of the lips as depth increases was recently measured by me in Corsica : rim width on a vertical cliff was of 20-25cm at a depth of 25 metres and grew to more than 2 metres at 45 metres deep, where rims were separated by intervalls of about one metre. (Figure 9). On deeper cliffs(55-65 metres) rim width tended to diminish and the lips to thicken and partially fuse together.

Fig. 9 : Structure of an algal rim on a cliff

inner structure : the general complexity of "coralligenous" algal formations is such that inner structure varies with such factors as depth, nature of the dominant species of bank building algae, abundance of sedimentation and the more or less important activity of rock-boring organisms (HONG 1980).

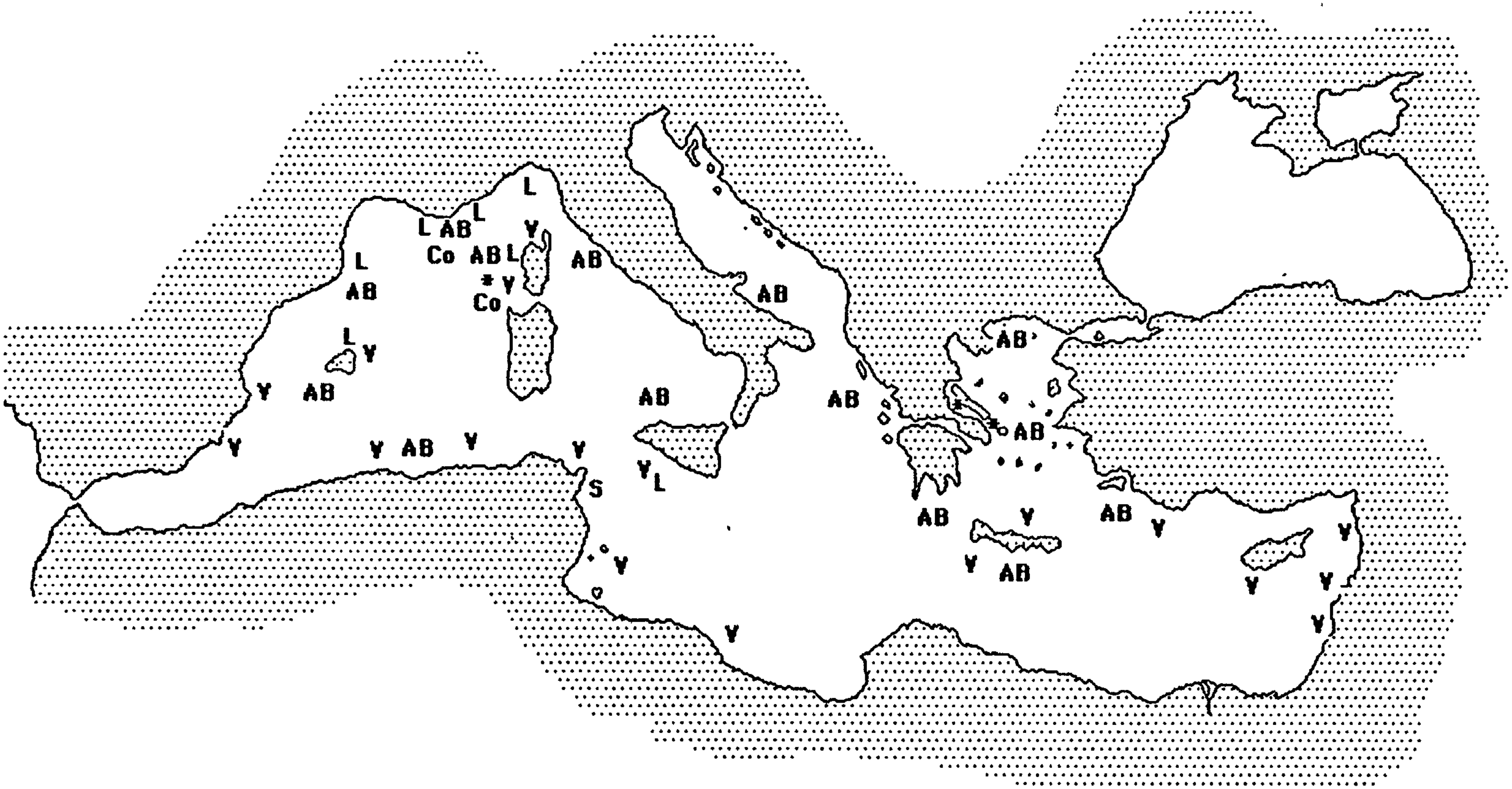
The great development of sponges may sometimes lead to the development of mixed banks of low mechanical resistance which crumble easily (LABOREL 1961).

Corings and drillings inside coralligenous banks have at present time never be attempted, but they certainly will be an interesting subjet of research in years to come.

The presence of important inner voids and cavities makes the algal banks an extremely rich and complex biotope, the fauna of which has been extensively studied (LAUBIER 1965, HONG 1980).

Geographical range

Coralligenous banks are very common all around the rocky coasts of the Mediterranean, at the possible exception of those of Lebanon and Israel. The best developed formations are those of the Egean sea, from Crete to Thasos (LABOREL 1961). Best studied places are the coasts of France, Corsica and eastern Italy.



Map : General repartition of biogenic buildings in the Mediterranean

L	Lithophyllum rim	*	Cladocora banks
V	Vermetid-algal rim	S	Serpulid reefs
Co	Corallina rims	AB	Algal Banks

BIOGENIC RIMS AS MARKERS OF PAST SEA LEVELS

The fluctuating nature of sea level, although it was understood only recently, is now an important background for archaeological studies in the Mediterranean. Variations of sea level have been active for millenia, a slow but powerful surf, driving whole civilizations in its wake. If wide scale fluctuations are now more or less documented, small scale displacements of the shore line are not always easy to trace and need combined studies of several kinds of specialists.

In that respect, the presence of eroded remains of biogenic rims above or under the present water line is a great asset : they may be conspicuous or not, but they are generally easy to date by means of radiochronometry, giving a very accurate determination of corresponding past levels and, last but not least, they are often found on rocky coasts where other types of markers (sedimentological, archaeological and son on) are difficult to find.

The results may give important hints about general elevation of the sea level in the past millenia or about tectonic or volcanic movements, sometimes asscociated with earthquakes (as in Crete : THOMMERET *et al.* 1983). This may be of important concern regarding coast stability and risks upon litoral cities.

Unfortunately there has been no general survey for biological sea level remains in the Mediterranean region but only regional studies for a limited number of regions.

Several types of biogenic buildings were used for that purpose : mostly Vermetid rims (FEVRET & SANLAVILLE, 1966, for Lebanon, THOMMERET *et al.* 1983 for Crete) and *Lithophyllum lichenoides* rim (LABOREL *et al.* 1983) for french continental and corsican coasts. Deeper living *Cladocora* and "coralligenous" banks have been little used, since they cannot give a good accuracy for the estimation of sea levels, but they will certainly be used someday for paleoclimatical studies, with the help of isotopic methods.

BIOGENIC CONSTRUCTIONS AS NATURAL MONUMENTS

The concept of natural monument is not a recent one, but it is presently developing and taking a wider extension. A natural monument must be something spectacular, of course, but, as our understanding of our planet grows, this concept tends to get more subtle and I think that many remarkable littoral or underwater sceneries may be called a natural monument. As our knowledge of mediterranean shores extends, many remarkable phenomena may be observed, which were completely unknown some years before and which now are worth protecting and visiting : among these are some of the more developed among the biogenic constructions in that region.

Unfortunately no general survey has ever been made of places which merit to be classified as "natural monuments", and if some of the more beautiful sites are already protected because they are situated inside Parks or Natural Reserves, many others are unsuspected and may be destroyed or spoiled without anybody taking notice as was the case recently for beautiful *Lithophyllum lichenoides* rims on the french island of Porquerolles which were killed by surface water pollution, and for vermetid ridges in northern Corsica which were smothered by detrital sands from a neighboring asbestos mine.

It is thus necessary to begin an international enquiry at the scale of the mediterranean basin, in order to complete our knowledge of these exceptional places and to try to put them under proper protection.

Some examples of "natural monuments" created by biogenic buildings around the mediterranean basin :

I shall try here, not to present an exhaustive list, which is of course presently impossible, but to give some examples of the sites that have already been described may be worth protecting on reason of their development. Generally speaking these formations are scarce, and have their maximum extent on a limited area.

Obviously enough, vast extents of coasts in many mediterranean countries have not been covered yet but I do hope that the few examples I quote here will help to realize that the survey is worth doing.

a) The *Lithophyllum* rim at Punta Palazzu, Regional Park of Corsica :

This is a remarkably beautiful place and natural formation, albeit completely unknown from the visitors of the Park. The site is a narrow canyon-like indentation, 100m long and 5 to 30 metres wide, cut into reddish volcanic cliffs.

On the vertical walls of the crevice, a lush growth of calcareous algae has created a continuous pavement-like rim which attains a maximum width of more than two metres, slightly over sea level. The rims on both sides are so developed that they bridge the chasm over at its narrowest part.

The rim surface is completely covered of palm sized cushions of light purplish algal thalli , hard and brittle as chinaware, which contrast strongly with the red walls and the deep blue of the water.

No description of the place has yet been published, but the study of underwater, vestigial rims allowed us to find and date traces of several past sea levels, going back to the Antiquity and the Bronze Age.

The site is located inside the Marine Reserve of Scandola, and is of difficult access, since surf may prevent entering the crevice for weeks and the sole access possible is by small boat. It is thus well protected from anthropic interactions, but is strongly exposed to the accumulation of wind-drifting refuse and spills which may accumulate for weeks in the crevice.

b) Algal-Vermetid platforms at Torre del Isola (Sicily) :

These platforms were discovered by the french naturalist A. de QUATREFAGES in 1854 who interpreted them erroneously as massive vermetid buildings. They have been described by MOLINIER & PICARD (1953) and it seems that no further study was made in recent years. From the brief description and photographs given by the latter authors it appears that the length and width of these platforms is somewhat remarkable.

Since the place is relatively far from Palermo, in a rocky environment of difficult access, (J. PICARD pers. comm.) there are reasonable possibilities that these very remarkable vermetdid platforms have not recently disappeared under the influence of pollution or human activities. It should then be interesting to make a new survey with the help of italian scientists and to ask for a protection of the site.

c) Vermetid platforms at Tipasa (Algeria) :

These have been described also by MOLINIER & PICARD but no recent study is available. They are built on the same model as those of Palermo with only small differences in the thickness of the algal vermetid layer. No photograph is known from these formations which are said (Dr J. PICARD pers. comm.) to be extensive and beautiful.

d) Vermetid platforms at Mikhmoret and Shikmona (Israel) :

These have been described by SAFRIEL, and are extensive vermetid rimmed eroded eolian platforms of some dozens metres diameter. (Mikhmoret) or rounded "microatolls" (Shikmona). They are certainly sufficiently developed to receive some kind of protection.

e) Vermetid platforms on the coast of Lebanon :

They have been described recently by DALONGEVILLE (1977), and occur on a long stretch of the lebanese coast from Tyr north to Tripoli. Associated with living platforms, many traces of ancient platforms corresponding to past sea levels have been described . Since the geographical range of these formations is wide (several hundred kilometres) and in the absence of more detailed descriptions it is presently not possible to select the more developed and interesting sites.

f) <u>Algal rim at Bahiret el Bibane, (Tunisia)</u> :

This closed bay lies on the south eastern tunisian shores, near the libyan border.

Recent papers by THORNTON *et al.* (1978) and by DENIZOT *et al.*(1981) have described this very beautiful formation, which extends for about 30 kilometres on the inner side of a sandstone spit separating an hypersaline lagoon from the open sea.

The remarkable morphology of the algal formations include "atoll"-like algal patches, fusing into straight algal ridges. The biological component is mainly *Neogoniolithon notarisii*, a normal component of the algal-vermetid rims, but vermetids appear to lack completely.

The Bahiret el Bibane reefs can best be interpreted as an impoverished vermetid-algal formation, in a very calm and hypersaline environment. it is at present a unique case with no other similar formation in the whole mediterranean basin and must certainly be protected and gain the status of natural monument.

f) <u>Ancient shores and recent formations in western Crete (Greece)</u> :

The western shores of Crete appear to be remarkably interesting since the island of Crete has undergone a strong and sudden tectonic tilting some 1500 years ago, which left extensive parts of its shoreline dry, preserving even the slightest details of coastal morphology and marine life (THOMMERET *et al.* 1981). Since very beautiful living vermetid platforms and "atolls" are also foud there (KELLETAT 1979) it could be interesting for this island to select a zone on its western coast for what could be a future Park.

The region of Falasarna should be ideal for that purpose since it contains three major elements of interest : i.e : an elevated ancient city and harbour, very fine traces of complex elevated shorelines and beautiful vermetid "atolls".

g) <u>*Cladocora* reefs in the Gulf of Atalanti (Greece)</u> :

Although not visible from the surface, these formations are unique in the Mediterranean and represent the only known case of what could be called a mediterranean coral reef. It seems interesting to promote a new survey with the help of greek scientists in order to select and protect at least a part of the gulf of Atalanti (Evboikos Kolpos) shores.

h) <u>The "coralligenous "banks</u> :

Coralligenous formations are such a common feature in the Mediterranean that it is very difficult to select interesting sites for protection. This is particularly necessary since "coralligenous" banks and rims build beautiful submarine landscapes, an important factor if one considers the great development of underwater sports.

Many marine parks and reserves already include beautiful banks which are thus protected : this is notably the case of the french parks : Parc National de Port Cros, Marine Reserve of Banyuls, and Marine Reserve of Scandola (which is part of the Regional Park of Corsica). Many other fine sites exist on the mediterranean shores of continental France, notably in the region of Marseilles . The absence of a general survey in the mediterranean area is a serious drawback and it will be necessary to launch an international inquiry . We already know that very interesting banks have been studied on the italian side of the Adriatic (SARA 1967-1969), but we know very few about spanish and north african shores. The most interesting region is of course the Egean sea (LABOREL 1960, 1961) where remarkable zones could be easily picked out if a research program was established with Greek scientists.

MANAGEMENT OF BIOGENIC CONSTRUCTIONS

It is too early to give a detailed account of what should be made to protect and to manage properly the more interesting biogenic constructions in the mediterranean region.

It seems that the best protection and management possible is to include these sites into any kind of protected zone (National or Regional Park, Marine Reserve and so on). The extension and beauty of biogenic formations may be such that the latter might be considered as the main component (or core) of the Park : this is the case for extensive vermetid formations and possibly also for the *Cladocora* banks. In some other cases, otherwise common formations may be included into Parks of more general scope as is already the case for the french parks quoted here. This applies mainly for coralligenous banks.

It will generally be necessary to present the general public with some kind of written or diagrammatic explanations about the nature, the biological components and the morphology, and care should be taken to obtain a proper supervision of visitors since biogenic formations are generally easily degraded by walking on them or taking "souvenir" samples. If such precautions are not taken, protection will not only be unadequate but sites will be degraded which were naturally protected when they were unknown from the layman and far from beaten tracks.

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