

## THE 'TREES FROM THE SEA' CORAL ARCHITECTURES AND INDIAN OCEAN MARITIME RESOURCES

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### ABSTRACT

This article presents the author's experiences, over the past twenty-five years, in coral stone architecture. The use of marine porite coral is a technology that unites different cultures around the Indian Ocean, from the Maldives to the Swahili coast in Africa. The paper focuses on the use of environmental constraints and local resources for the construction of maritime mosques and coral buildings. The pre-Islamic origin of coral architecture is located between India and Indonesia around the first century AD. The diffusion of this technology was supported by Abbasid travellers and merchants in the Western Indian Ocean, and in Africa around the 9<sup>th</sup> century, as well as its globalisation under the Buwayhids and the Fatimids in the 11<sup>th</sup> century. This article shows how international maritime trade and Muslim diasporas disseminate a unique technology and how local populations assimilate material cultures, new technologies, new building material and how they share a common Indian Ocean identity.

**Keywords:** Coral stone, Indian Ocean, Swahili, Maldives, Islamic, Abbasids, Buddhism

### INTRODUCTION

A lot of new publications and research have been undertaken across East Africa, the Arabian Peninsula and the Indian subcontinent leading to fresh insights on Indian Ocean cultures. Some of these studies focused on local and regional histories in East Africa, Yemen, Oman, and India. Most of the time, Islamic architecture is presented as a local variation or a peripheral version of the "classic" medieval Middle Eastern models. In fact, pre-Islamic trading networks played a very important role in the process of the acquisition and transfer of knowledge and technologies (Wormser, 2014: 123-136) and the cultures around the Indian Ocean should be reinterpreted on the longue durée and in a global context. Fernand Braudel's work on the Mediterranean is a fine example of a work to use, to gain an understanding of the Indian Ocean worlds (Figure 1). Cultural contacts and exchanges were facilitated by the sea as an interface between

different regions. Stone building is generally attributed to the Greeks, Romans, Nabateans, and Sasanians and many of the Late Antiquity buildings in the Red Sea were built with fossil coral limestone found on the mainland (Power, 2012: 38-41). And this is probably where the main confusion arises: researchers and scholars call this "coral stone" limestone and fresh coral without differentiating between the fossil coral stone and the fresh marine coral. The fossil coral stone is a limestone found all along the Red Sea, the Persian Gulf and the Indian Ocean and it is the geological substratum of the coast. The littoral societies around the Indian Ocean had no other local resource than this limestone. The extraction and the use of fossil coral limestone does not differ from any other limestone found, for example, seashell limestone around the Mediterranean and therefore coral limestone buildings cannot be considered as a specificity of the Indian Ocean Cultures.

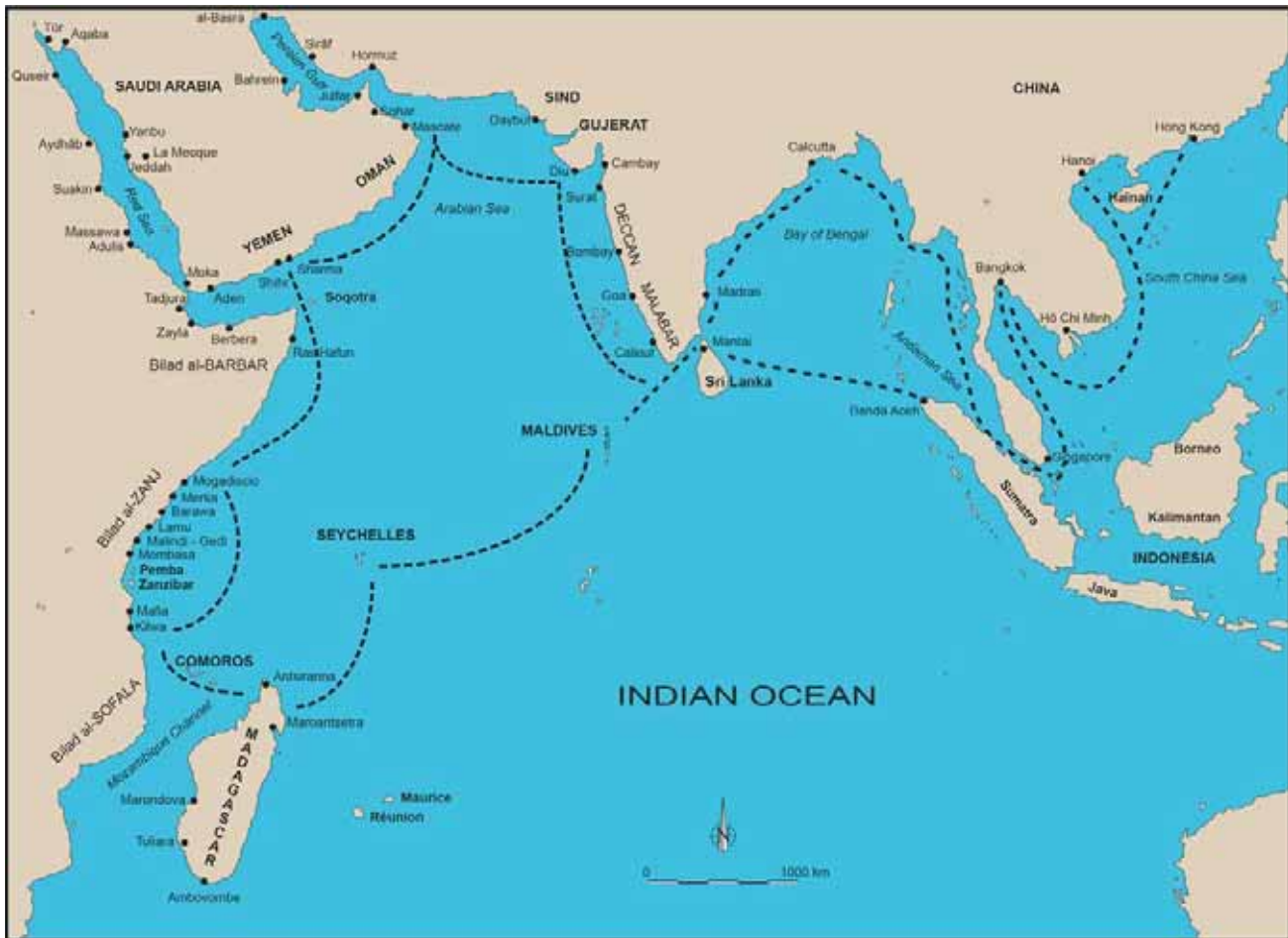
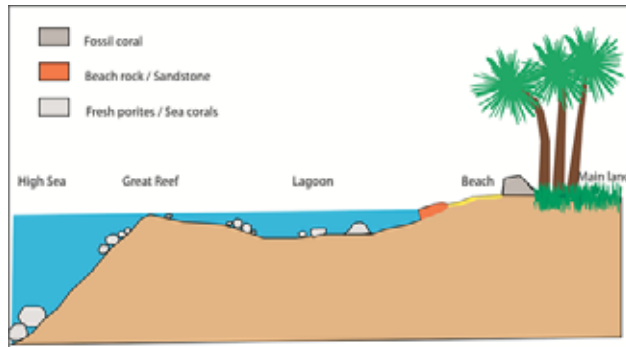


Figure-1: Map of the Indian Ocean and the sites mentioned.  
Source: S. Pradines

The fresh madreporite or porite coral is a specific building material that can be related to the Indian Ocean cultures. The coral reefs are present all around the Indian Ocean, Red Sea and Persian Gulf and provide natural resources of building material (Jameel, 2016: 49-57). The use of sea coral in construction is a technique that connects different cultures around the Indian Ocean. It is clearly a technique linked to the maritime people. Probably, the fresh porite coral was originally used because of the lack of other building material resources (stone, wood and clay), as was the case in the Maldives where no other resources were available. Thereafter, this technique was introduced into other parts of the world as a cultural choice. Sea corals were used as building material for construction in the Indian Ocean. What is meant by coral stone is the fresh living organism or marine corals called coral porites or madreporite. They are dense material, spherical or hemispherical in shape. Live coral reef boulders or porite corals were removed from the seabed in the lagoon between the beach and the great barrier of

coral (reef). The porite coral can grow to a massive size, in the form of huge boulders. The smaller blocks (20cm to 50cm) were collected directly on foot at low tide. Fine madreporite coral can grow to a huge size. These huge boulders can also be found in the lagoon but never in shallow water, and the highest-quality blocks can be found around the reef (Figure 2). They were hoisted from boats by ropes and brought to the shore. Live coral reef boulders or porite coral were cut into construction blocks while still fresh and soft and then they were air-dried before being used for construction as coral starts to get harder as it's dry. Corals are eminently suitable for architectural and sculptural works as they are lightweight and easy to carve. Unfortunately, corals are also extremely fragile and prone to breakage.

The environment is extremely important, especially in remote islands with limited access to building material such as wood and earth (clay) like in the Maldives. But it is not just about ecology and determinism: the use of fresh porite coral is



**Figure-2:** Section of the Indian Ocean shores from the beach to the great coral reef.  
**Source:** S. Pradines.

also a cultural choice. People could have built their monuments using only terrestrial resources such as coconut trees and beachrock (for the Maldives) or basalt stones (for the Comoros) but they decided to use marine coral. A technique defines a culture and a population. It constitutes the way that objects and gestures are used and how raw material is shaped (Leroi Gourhan, 1945). The use of fresh porites, madrepora or marine coral is a technique and a technology around a raw construction material. This technique unites different cultures around the Indian Ocean, not only in East Africa but also on the shores of Arabia, the Maldives and Sri Lanka to build temples, mosques as well as houses.

The Indian Ocean was not on the periphery but at the centre of the Muslim worlds. During the 9<sup>th</sup> century and the Abbasids, the use of Arabic as a vernacular language was not only as a ‘scaffolding’ to facilitate the exchanges, but also the pivot to transform in depth local societies with the conversion to Islam of the local Elite and then the remainder of the population (Pradines, & Topan, 2023: 1-15). One religion, Islam, united different cultures from various backgrounds from the Red Sea and Arabia to Persia and the Gulf, up to East Africa, India, the Maldives, Sri Lanka, and Indonesia. This article tries to understand how Muslim diaspora, travelers, traders, and refugees disseminate technology and how local populations assimilate material cultures, new technologies and new building material. Our research methodology is based on the results of our archaeological excavations in East Africa and the Maldives, architectural history, and literature of the Indian Ocean region.

## SWAHILI CORAL BUILDINGS

The Swahili Coast is a large region that extends over six modern days countries: Somalia, Kenya, Tanzania, Mozambique, Comoros, and Northern Madagascar. The word, *wa-swahili*, means the people of the ‘sahel’, the Arabic

term for the ‘shore’. This vocabulary was introduced during the colonial period and the 19<sup>th</sup> century, although the Muslim geographers such as al-Masudi, Idrisi, Yakut and Ibn Battuta used the term of ‘*Zanj al-Bahr*’ which referred to the ‘sea of the black people’ (East Africa) (Freeman-Grenville 1962: 29). The word ‘*Zanj*’ dates to the Antiquity and from the Greeks who used the term of ‘*Azania*’ to describe the East African coast. The Swahili described themselves according to their region, island, or town of origin. For the example, *wa-Mvita* are the people from Mombasa. Still Swahili identity remains much discussed, and it is a multifaceted culture, incorporating populations from diverse backgrounds: Austronesian, Bantu, and Nilotic. Swahili culture reflects neither a specific ethnic group nor a particular nationality.

The marginal position of the Swahili is linked to our Occidental vision of the Indian Ocean. In fact, the Indian Ocean provided a connection between Africa, Arabia, and Asia. The Swahili culture stands in-between Muslim and African worlds, resulting in the development of a unique coastal civilisation based on trade (Pouwels, 2000; Sheriff, 2002: 63-81). The Swahili were dynamic players in the Indian Ocean, equal to Arab, Persian, and Indian merchants and sailors. Nearly 500 Swahili archaeological sites have been identified in Africa, extending over 3,000 km of the coastline (Pradines 2004: 18-20). The lifestyles on the East Coast, the Comoros and Madagascar were homogenous due to the dissemination of new ideas and techniques by maritime travellers. Swahilis share the same religion, Islam, the same language, the Kiswahili, the same social organisation, and the same architecture.

Coral stone construction techniques can be divided into four phases according to the archaeological excavations lead by Mark Horton in Shanga, Lamu, Kenya and Stephane Pradines in Gedi, Kenya, as well as Sanje ya Kati, Tanzania and Mayotte, Comoro archipelago (Horton 1996; Horton, and Middleton, 2000; Pradines, 2010).

The first phase started between the 9<sup>th</sup>-10<sup>th</sup> centuries, first with small blocks of marine coral boulders or Porites bound together by a clay mortar. The coral blocks were collected at low tide to be used, raw and undressed, used for the foundations of walls, or they were occasionally inserted into wattle and daub walls. These techniques are recorded for the 9<sup>th</sup> and 10<sup>th</sup> centuries in Shanga in the Lamu Archipelago and Dembeni in the Comoros Archipelago (Horton, 1996: 224-242 and Pradines, 2019: 113-117).

From the 11<sup>th</sup> to the 12<sup>th</sup> century, the masonry techniques suddenly changed and were highly elaborate. These new



buildings were exclusively made using dressed porite coral stones bound together by a very fine lime mortar. The dressed coral porites blocks were cut into small square ashlars and laid out in horizontal courses to construct mosques and storehouses (Pradines, 2010: 27). This type of masonry is visible on the sites of Sanje ya Kati site in Kilwa Kisiwani (Pradines, 2009: 17). In Sanje ya Kati, the houses, mosque, and fortifications form a homogeneous architectural complex with the same building techniques consisting of horizontal courses of quadrangular ashlar of marine coral (Figure 3). A high-quality lime mortar was applied between the courses and the joints of the masonry. Sanje ya Kati was a very well defined and planned architectural project, and the building techniques are remarkably skilful. Although this technique was used until the 12<sup>th</sup> century, it was a lengthy process and it was difficult to construct many buildings, as the fresh porite coral blocks needed to be dragged from the shore during low tide and the larger blocks had to be hoisted directly from the sea.

Most of the so-called “Shirazi mosques” date back to this period and these mosques seem to have had consistent proportions; for example, in Gedi, the first mosque was approximately 10m by 7 m; in Tanzania, the Great Mosque of Kilwa was erected between 1131 and 1170, and its initial rectangular plan does not differ from the model previously described, measuring 11.8m by 7.8 m (Figure 4). The mosque of Sanje ya Kati, founded in the second half of the 11<sup>th</sup> century, measures 10.21m by 9.46 m; in Shanga, the mosque, constructed measures between 10.15m and 10.35m, and forms a rectangle measuring 11.22m by 7.21m. The Islamisation of the Swahili coast was connected to Shi'a diasporas coming from Yemen, the Gulf, and the Sindh (Pradines, 2009: 19-23). In Zanzibar, the oldest-known Swahili mihrab completely preserved is indicative of these transoceanic influences. The mihrab of Kizimkazi is decorated with a passage from the Qur'an and bears the date 1107. The niche of the mihrab is decorated with floral kufic inscriptions along the capitals and within the niche.

During the 13<sup>th</sup> century, the use of fresh coral declined in favour of fossil coral limestone. The Swahili masons kept the usual carving technique of quadrangular blocks, but they abandoned marine coral in favour of masonry of fossil coral limestone blocks. The quadrangular blocks were assembled on horizontal courses with thick mortar beds and consistent levelling. The masonry of the caravanserai of Husuni Ndogo in Kilwa Kisiwani is representative of this technique and transitional period.



**Figure-3:** Sanje ya Kati 11th-12th century house and horizontally positioned courses of ashlar blocks carved from marine coral.  
**Source:** S. Pradines



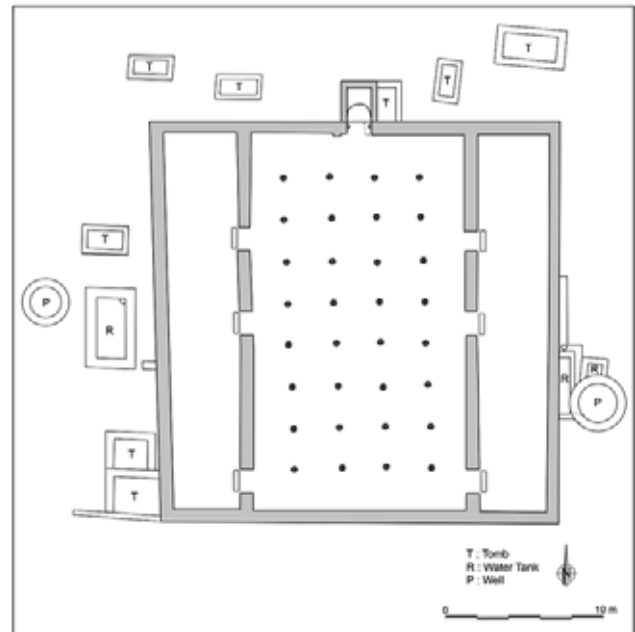
**Figure-4:** Great Mosque of Kilwa (Tanzania) Northern part 1131 and 1170.  
**Source:** Cyark Google Arts

The fossil coral limestone forms the geological substratum of the entire Swahili coast, found also on the Red Sea and the Persian Gulf (Hawker, 2008: 56). The blocks were extracted from open-air quarries, a few hundred metres from the seashore. The limestone which is found close to the seashore cannot be used because it is too porous and too hard to carve. When the bedrock does not appear as an outcrop, the workers had to expose it by scraping away the topsoil above it. As the coral limestone is a very soft material, the extraction techniques need to be quite rudimentary, i.e. a quarry face is created in the rock mass where the workers isolate blocks by furrowing all around them using picks (Pradines, 2004: 329-331) (Figure 5). This means that the blocks can be uprooted from the natural substrate by means of leveraging using an iron bar or a mace. The blocks are then squared off using a toothed chisel or even a simple machete. The resulting offcuts and debris are then collected and used as rubble stones.

In the 13<sup>th</sup> and 14<sup>th</sup> centuries, stone architecture became widespread. And eventually, mosques and houses reached large dimensions, such as that in Gedi, the great mosque measured 26m long at the end of the 14<sup>th</sup> century (Figure 6) (Pradines 2011: 131-149).

From the 14<sup>th</sup> century onwards and the expansion of the Swahili stone towns, the builders started to use standard masonry techniques, which were more easy to use with irregular chips of fossil coral stone bound together in a thick lime mortar. The limestone was not cut into regular ashlars with horizontal courses as before, but rather was made up of small irregular blocks bound together in large masonry walls made using the rammed-earth technique between wooden planks. Some walls were made of red clay (instead of lime mortar) and coral limestone like in Gedi (Pradines, 2010: 111-157) and other walls were made of lime mortar and coral limestone like the palace of Husuni Kubwa in Kilwa Kisiwani and the stone houses in Songo Mnara and the buildings in Kua (Figure 7) (Pradines and Blanchard, 2015: 9-33). The walls of most of the Swahili buildings were between 40cm to 54cm thick, which equates to the Swahili measurement known as *dhira* in Arabic: the distance between index and elbow (*coudée, fr.*). The masonry was composed of fossil coral limestone rubble measuring approximately 20cm in diameter each randomly placed in a red clay or lime mortar. Examples of red clay mortar were observed in Gedi. The lime is produced by the calcination, at high temperatures, of the marine or fossil coral blocks. (1000° C). The resultant calcium oxide is then hydrated, and forms slaked lime. For the fabrication of plaster, imported gypsum was replaced by the plant juice known as *kowe*. The walls have a stratified appearance as they were erected using a timber formwork which was removed after drying. They often fragment into blocks of between 60cm and 1m

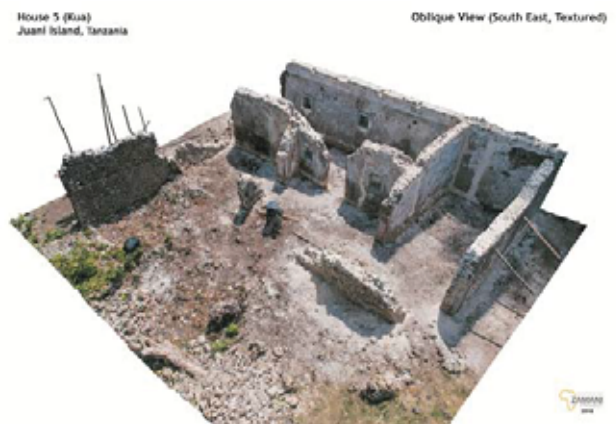
high creating a levelled side at the top which is the top face of the superior wall. The sides of the walls reveal imprints from the formworks and circular or square holes spread out horizontally every metre. At the beginning of the 15<sup>th</sup> century, the houses in Gedi were pierced with a series of square holes measuring 20cm on each side, spaced out horizontally every 1m to 1.4m. The purpose of these putlog holes was precisely to fix the formwork and the holes mark the place where the lower screws were positioned and where



**Figure-6:** Pln of the Great Mosque of the 14th century Great Mosque. **Source:** S. Pradines



**Figure-5:** Workers and coral lime stones mining techniques in Manda Island, Lamu archipelago, Kenya **Source:** S. Pradines



**Figure-7:** Rammed-earth or concrete technique with mortar and fossil coral rags in a 16th century house in Kua, Mafia archipelago, Tanzania. **Source:** Zamani, AKU



they held the form ties of the panels in position during construction. The 'banches (fr.)' are the planks of wood between which the layers of mortar and stone are laid. The timber putlogs which traversed the walls, could also have been used to hold up scaffolds which had no upright supports. These scaffoldings were indispensable when it came to supporting both the masons and their tools at great heights.

The fresh marine coral was not completely abandoned by the Swahili. From the 13<sup>th</sup> to the 17<sup>th</sup> century, the porite marine coral was still dressed and used only for fine sculptures around the mihrabs in the mosques, or for the door frames and niches in large stone houses and palaces (Figure 8) (Pradines, 2003: 355-381; Pradines, 2010: 159-180). The mihrab of the Friday Mosque and the door of the courtyard in the palace of Songo Mnara are fine examples of 15<sup>th</sup> century works (Figure 9). The quoins at the corners of the doors, the windows and niches were carved at right angles from marine coral blocks. The two visible salient were carved smoothly, with the remainder of the irregular block being immersed in the masonry. The mouldings of the arches and plaques bearing the epigraphic of the tombstones were

also carved from the marine coral, similar to the 15<sup>th</sup>-century pillar tombs in Gedi and the 17<sup>th</sup>-century tombs of Kua (Figure 10).

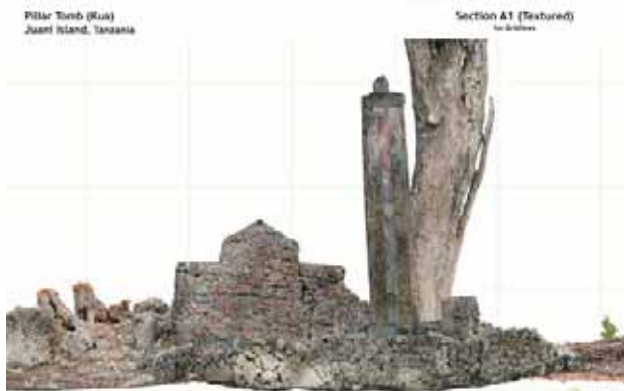
At the beginning of the 18<sup>th</sup> century the use of fresh porite marine coral was completely abandoned in favour of door frames, arches, niches (*vi-zidaka*) and mihrabs made of thick stucco mouldings and decorations like in Yemen, Oman, and Gujarat. The coastal architecture of the Swahili is often opposed to African vernacular architecture from the hinterland, which is based on wood and earth. However, most of the Swahili houses were (and are) made of mud and thatch, only public buildings, religious buildings, palaces, and storehouses were made of coral stones. Then, the use of stone in African architecture is well-known across the High Plateaux, from South Africa to Somalia. (Gillman, 1944: 44-55; Gillman, 1945: 64-66; Onjala, 1998: 22-23; Wynn Jones, 1941: 11-12; Jackson, 1948: 77-78; Fosbrooke,



**Figure-8:** 15th century houses in Gedi and niche situated at the back of the house.  
**Source:** Pradines



**Figure-9:** Fresh marine coral door frame in the palace of Songo Mnara a 15th century Swahili site.  
**Source:** Pradines



**Figure-10:** 17th century pillar tomb of kus, Mafia archipelago, Tanzania.  
**Source:** Zamani, AKU

1954: 115-129; Fagan, 1985: 571-599; Phillipson, 1993) What is exogenous, and characteristic of Swahili architecture is the coral and limestone carving techniques, as well as the use of marine coral and lime mortars. The progressive use of marine coral and its introduction into coastal architecture became widespread in the 9<sup>th</sup> century with the intensification of trading relations with the Abbasids, thus creating a close link between international trade, Muslim merchants, and the spread of coral architecture in East Africa.

## MALDIVIAN CORAL ARCHITECTURE

The Maldives are located offshore at the South-West of India, the archipelago is composed of atolls with 1,196 islands. The Maldivians have around 200 Friday mosques which equates to practically one mosque per inhabited island (Forbes, 1983: 67-68 and Reynolds, 1984: 61-64). The best feature of the Maldivian mosques is their building material: huge blocks of sea coral. The first serious description of Maldivian buildings was done by the French traveller, Parmentier in 1529. Parmentier provided a very good description of a stone coral mosque in Fua Mulaku Atoll. He described beautiful constructions made without using mortar. Later, between 1602 and 1607, another French sailor, Pyrrard de Laval, described full of admiration the carpentry techniques of the coral mosques in Male (Forbes, 1983: 52-54). Finally, in 2016, Mauroof Jameel published the first book on Maldivian mosques with a catalogue which included plans and maps (Jameel, 2016: 97-111). According to Jameel, the first Maldivian mosques (1153-1514 AD.) were very simple and had no intricate decorative carvings (Jameel, 2016: 53 and 88-91).

As mentioned previously, the exceptional architectural feature of the Maldivian mosques is the use of natural and local



**Figure-11:** Coral stone buildings without mortar and wood techniques with peg holes, Meedhoo island raa Atoll.  
**Source:** S. Pradines

resource: the sea coral. As there is no stone available on the Maldives, builders had to use fresh coral from the sea and sandstone from the shore (beachrock and pudding stone). Three kinds of stones are used in the Maldives: *hiri-ga* or white porite coral, *veli-ga* or yellow sandstone and *rat-ga* or red pudding stone (Forbes, 1983: 70). The Maldivians developed their own technology without mortar, supported by their boatbuilding skills (Figure 11). The coral stone cutting and dressing techniques were identical to the wood techniques and sewn boats with peg holes. Locally, the coral stone carpentry is known as “*hiri galu vadaan*” (Jameel, 2016: 54-55). Porite coral or *hiriga* is assembled without plaster or mortar. Interlocking techniques without mortar (dry stone techniques) emanate most probably from Gujarat in India. The carpentry techniques used for coral stones were like those used for trees. Coral is considered by Maldivians as ‘living trees from the sea’; and indeed, coral is an animal and not mineral. Four types of technologies were used for the construction: tongue and groove joints, dovetail joints, dowel, and peg joints (boatbuilding) and the lap joints (zig zag) Figures 12 & 13. During the British colonial period, a new and faster construction technique was introduced, using chipped coral stones (porite and fossil) bound together by mortar and plaster. The coral was burned to produce lime. The use of lime was introduced in 1800 with coral chips. The coral stone in the Maldives appears to be lime washed and is very white. The exposed parts are sometimes oxidised and dark grey. Maldivians also used bedrocks from the seashore, coral sandstone and coral limestone (fossils or skeletons). Other kinds of stones were used, such as sandstone (*veligaa*) and the conglomerate (*pudding*) beachrock found on the shores, and in the island the coral bedrock called fossil coral stone or coral skeletons. A sandstone mosque is recorded in Fuvahmulah and dated from 1300. We found a similar monument near the great





**Figure-12:** Coral construction dovetail joints and lap joints (zig zag), Meedhoo island raa Atoll.  
Source: S. Pradines



**Figure-13:** Coral construction tongue and groove joints, water tank in Fenfushi.  
Source: P. Pradines



**Figure-14:** Hukuru Miskii, Old Friday Mosque of the capital Island of Male (Kaafu Atoll).  
Source: S. Pradines



**Figure-15:** The decorative programme of the Eid Mosque in Male (Kaafu Atoll).  
Source: P. Pradines

mosque in Fenfushi.

The results of our recent archaeological excavations to the north of the Maldivian Atolls on Fenfushi Island, Ari Atoll and in the southernmost part of the Maldives on Hulhumedhoo Island, Addu Atoll, are showing the same thing: the Maldivian mosques have been strongly influenced by Buddhist architecture (Pradines & Balestra, 2021: 200-226) Figures 14 & 15.

However, according to our excavations, even though some mosques might have reused some building material from pre-Islamic monuments, the Maldivian mosques were not built on Buddhist temples. The coral stone mosques of the Maldives simply demonstrate the continuity and the strong influence of Buddhist architecture on the local Islamic architecture as previously mentioned by H.C.P Bell (Figures

16 & 17). These influences consist of raised plinth podiums, the use of public wells, and bathing or water tanks (*baoli*) Figure 18. The mosque's podiums have carvings and mouldings with Buddhist critical motifs decorations. The Maldivian mosques are also oriented to the North like Buddhist temples instead of being turned in the direction of Mecca (*qibla*).

How old is the tradition of coral stone construction and where did this technique originate? One fact is confirmed, Coral stone construction methods or coral stone carpentry existed as early as the Buddhist period and it is a pre-Islamic tradition (Forbes, 1987: 281-288). The use of coral construction continued until the introduction of mortar masonry by Europeans in the late 18<sup>th</sup> century.

The first settlers in the Maldives were most probably migrants





**Figure-16:** Old Mosque of Isdhoo Island (Laamu Atoll) influenced by Buddhist traditions especially the steps at the entrances.  
Source: S. Pradines

from Kerala or Sri Lanka in the 5<sup>th</sup> or 4<sup>th</sup> century BC (Forbes, 1983: 43-44). Sri Lankans converted to Buddhism around 250 BC All dates are AD or CE unless otherwise specified. and Buddhism was firmly established in the Maldives between the 1<sup>st</sup> and 2<sup>nd</sup> centuries AD (Bell, 1940: 16-17). Several examples of Buddhist monasteries have been recorded in the Maldives and date from 165-345 AD (Bell, 1940) and they were made of fine madrepore coral stone (Forbes, 1983: 46). The Buddhist architectural influences from Sri Lanka in the Maldives are visible in the monastery of Polonnaruwa, which have raised plinths and decorative stone mouldings like the Maldivian mosques (Jameel, 2016: 78-79). Undoubtedly, the coral technique arrived in the Maldives from Sri Lanka with the Buddhist culture from at least the 2<sup>nd</sup> century AD (Jameel, 2016: 51; Jameel, 2018: 17-27).

Islam was slowly introduced to the Maldives by merchants coming from the Malabar Coast between the 7<sup>th</sup> and 8<sup>th</sup> centuries (Forbes, 1983: 47; Carswell, 1976: 26-30; Carswell,



**Figure-17:** Friday Mosque of Ihavandhoo (Ihavandhoo Island, Haa Alifu Atoll) and decorative Programme after the construction of the Building.  
Source: P. Pradines

1977: 138-139). The Maldives were known and called “Dibajat” or “Dabigat” in the 9<sup>th</sup> -10<sup>th</sup> c. Arabic sources (Ducène, 2013: 132-33). According to local traditions and the Arab traveller Ibn Battuta, all the Maldivians converted to Islam in 1153 with the conversion of the king who became the first sultan of the archipelago (Kalus & Guillot, 2005: 35-36). The people of the capital city Male broke their idols, razed the Buddhist temples to the ground. According to previous research, Bell mentioned a *Pirivena* (a monk’s residence) that was destroyed on Gan Island in Addu Seenu Atoll, and its foundations converted to a mosque during the 12<sup>th</sup> century (Forbes, 1983: 50-51). However even if Buddhist temples were destroyed, Maldivians kept the same building techniques and architectural traditions.

## ORIGIN AND DIFFUSION OF THE CORAL STONE TECHNOLOGY IN THE INDIAN OCEAN

The last part of my paper is discussing origins, history, and cross-cultural influences in building techniques and Indian Ocean coral architecture. As described previously, the best examples of coral stone architecture can be found in the Maldives and in East Africa. Maldivians and Swahilis used the same materials, porite coral and coral limestone, but their techniques were different. Swahili architecture uses mortar and plaster, and it is much simpler than the Maldivian masonry techniques. The use of coral stone in the Maldives reached a peak that no culture of the Indian Ocean managed to attain Figure 19, and it is also one of the oldest of her kind with evidences of Buddhist monuments built with these techniques during the 1<sup>st</sup> or 2<sup>nd</sup> centuries AD. The fusion of ancient construction techniques with new building material, the sea coral led to the emergence of the Buddhist temples and later the Muslim mosques of the Maldives Figure 20. This architecture was forged by Indians, Sri



**Figure-18:** Aasaary Mosque, Friday Mosque compound on Fenfushi Island (Alifu Dhaalu/Ari Atoll).  
Source: S. Pradines





**Figure-19:** Friday Mosque, Fenfushi Island Decorated with carved coral pannels with islamic arabesques and Malay floral interwoven patterns.  
Source: P. Pradines



**Figure-20:** Fandiyaaru Mosque in Koagannu Cementery's in Hulhumeedhoo Island, Addu Atoll.  
Source: P. Pradines



**Figure-21:** Fossil coral limestone buildings in Quseir al Qadim a Roman site on the Red Sea.  
Source: P. Pradines

Lankans, Malaysians, Arabs, Persians, Indonesian, and Africans (Jameel, 2012).

Environment had a first role to play, especially in remote islands which had only limited access to wood and not even clay for earthen constructions. The coral reefs exist all around the Indian Ocean, Red Sea and Persian Gulf and provided natural resources of building material (Jameel and Ahmad, 2016: 49-57). However, it was not only about ecological determinism; the use of fresh sea coral was a cultural choice for some populations. The builders had to collect blocks at low tide or even to pull out from boats huge coral blocks from the sea. Maldivians and Swahili could have built their mosques and houses only with coconut trees and fossil coral stone, but they decided to use fresh sea coral. Then, building materials and building techniques are two different things (Leroi Gourhan, 1945). A technique defines a culture, a

population or even an individual artist. It constitutes the way that objects and gestures are used and how raw material is shaped. Coral construction technology was a cultural choice that united different cultures around the Indian Ocean to build not only mosques, but also temples, palaces, and houses. It is a technique linked to maritime peoples.

To understand the genesis of sea coral masonry techniques, it is important to look at fossil coral or coastal limestone technologies around the Indian Ocean, Red Sea, and the Gulf. With regards to the origin of coral stone architecture, the earliest littoral stone constructions in the Red Sea are connected to Greek or Roman technologies. The Sudanese Island of al-Rih on the Red Sea has Greek buildings, dated between BC 323 and 146 made of fossil coral stone. Coral stone buildings are also recorded in Sudan during the Late Antiquity and Medieval periods in Aydhav and Suakin. The same technology is recorded for the Yemeni coasts during the Medieval and modern periods in port cities such as Mokka, and Aden etc. (Bonenfant, 2000) Fossil coral limestone buildings were constructed all along the shores of the Red Sea. In Egypt, Quseir al-Qadim was built with fossil coral stones during the Roman and early Islamic periods (Figure 21). In the Sinai, the Nabatean fort of Dahab was built with fossil coral limestone (Meshel, 2000: 18-47); and, in al-Tur, the caravanserai of al-Raya during the Abbasid and Fatimid periods, was constructed using the same material. During the third century, the decline of Rome left the area open to the Axumites and Sasanians, who controlled navigation in the Red Sea and the Gulf until the sixth century (Desanges, 1999: 351; Keswani, 1980, 41 and Chittick, 1980: 117-127). The Christian kingdom of Axum reached its peak between the 4<sup>th</sup> and 6<sup>th</sup> centuries and the great Aksumite port of Adulis functioned as a relay from Alexandria on the Red Sea (Ducellier, Kaplan et Martin,



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1990: 54). A Greek merchant native to Alexandria, Cosmas Indicopleustes, recounted his passage through Adulis on his way to Sri Lanka in 525 (Cosmas Indicopleustes, 547 in Freeman-Grenville, 1962: 5). Arrived in the Gulf of Aden, the Roman ships did not make a direct connection to India or Africa, but they were relayed by Aksumite or Yemeni ships (Desanges, 1999: 323 et Desanges & Reddé, 1994: 161-194). A fierce rivalry opposed in the Red Sea, the Persians and the Byzantines from 552 to 575 AD; the Persians supporting the Jewish kingdom of Hymar and the Byzantines supporting the Ethiopian kingdom of Aksum (Bowersock, 2013: 106-119).

Many buildings in the Gulf were constructed of fossil coral rock (Arabic *farush* or *hasa*; Persian *sang-i marjan*) (Kervran, Hiebert and Rougeulle, 2005; Hawker, 2008). Bahrain and Qatar used coral blocks (Hardy-Guilbert and Lalande, 1981; Hardy-Guilbert, 1985: 23; Kervran 1990: 31-48). Ras al-Khaima people in the Emirates used fresh coral stones called *hajar al-bahr* or “stones of the sea”. The collection of coral from shallow water was taking place mainly in the summer months. Fossil coral stone buildings are to be found all along the shores of the Persian Gulf from at least the Sasanian period (Kervran, Hiebert and Rougeulle, 2005: 118-119, 200). Following the weakening of the Roman Empire and the disintegration of the Parthian Empire, the Sasanians became great commercial intermediaries, The king Ardashir I place subjugated the kingdoms of Kushan, Turan, Makran and Bahrayn (Fiorani and Besenval, 1990: 133-136). The Sasanians controlled all the sea routes in the Persian Gulf from the 3<sup>rd</sup> century AD. The great Sasanians ports of Sohar and Siraf at this time drained all the trade and goods transiting between Africa and India. The Sasanian king Vahram V (421-438) even married an Indian princess and received as endowment the city of Daybul (now the site of Banbhore), this port of the Indus delta was the most important crossroad at that time between Yemen and Sri Lanka Sassanians were in Sri Lanka during the 6<sup>th</sup> c. (Fiorani et Besenval, 1990: 140).

The Romans (196-206 AD.) and, later in the 6<sup>th</sup> century, the Sassanians had trading posts and customs in Srie Lanka and warehouses in Aden (Fiorani and Besenval, 1990:E140; McLaughlin, 2018: 170-171). On the northwest coast of Sri Lanka, the ancient port of Mantai was occupied during 1500 years of occupation until the demise of the town in the early 11<sup>th</sup> century. The development of the settlement started really from 200 to 300 AD. with complex buildings in the central part constructed with fired bricks and fresh coral. In all areas, archaeologist observed remains of destroyed buildings made of fire bricks and sea coral stones (Carswell,

Deraniyagala and Graham, 2013: 157-168). Graham mentions a central building in Mantai made of sea coral stone and red bricks Excavated by Hocart in the 1920s (Carswell, Deraniyagala and Graham, 2013: 417-418). Buddhism arrived in Sri Lanka around 250 BC. Unfortunately, the real impact that the Romans had on local Sinhalese architecture is unknown. However, it is possible to observe a strong influence of Sri Lankan Buddhism in Java (Indonesia) especially in the construction techniques. The cutting techniques in Borobudur in the 8<sup>th</sup> century were inspired by Sri Lankan monuments (Dumarçay, 2003: 21-23). The carpentry techniques have inspired the stone builders like in the Maldives with cramps being carved in stone in the dovetail technology. The horizontal realignment of the courses was forced by means of cornerstones (in the style of keystone). This technique, which originated in Sri Lanka, was used as from the 8<sup>th</sup> century in Mihintale (Java). New construction techniques arrived in Java with a second wave of Hinduisation in the 9<sup>th</sup> century comprising mortice and tenon joining systems. However, unlike the preceding phase, the mortice and tenon assembly was within the stones and, as in the Maldives, forms a slide. In the Maldives the two techniques are known but, currently, there is no attempt at providing a chronology of these architectural implementations. The Sri Lankan example seems to be the most likely candidate for being the origin of this carpentry technique and naval construction from stone cut applications, techniques that spread to the Maldives and Java (Indonesia) (Dawson & Gillow, 1994; Tajudeen, 2014: 121-138; Feener & Ali, 2021; O’Kane, 2023).

The 11<sup>th</sup> and 12<sup>th</sup> centuries represent a period of profound economic change in the Indian Ocean networks, with numerous ports and urban centres being created at that time in East Africa and Arabia (Rougeulle, 2015: 1-8). Swahili oral traditions mention frequently Shirazi and wa-Debuli as main builders and founders of many East African cities. These people were undoubtedly refugees or merchants who came from the Ports of Siraf and Daybul. Similar traditions exist for port-cities in the Red Sea, such as Aden and Jeddah; and Ibn al-Mujawir mentioned the arrival of Persians who emigrated from Siraf after 1080 AD (Ducatez, 2003: 147, note 65). These migrants were apparently great builders responsible for the construction of many monuments such as mosques, caravanserais, wells, town walls, and cisterns. To conclude similar oral traditions, exist up to the Maldives where, a Shirazi was credited to have introduced mosque construction in the Archipelago in 1153.

India seems had an important role in the genesis of Swahili and Maldivian architectures (Donley-Reid, 1991). Maldivian

architecture shares similar architectural features with South Indian temples such as raised plinths, rising stairs, exterior decorative stone mouldings for example in the temple of Lad Khan in Karnataka, built in 500 CE, and the Brihdeeswarar temple in Thanjavur, built in 1010 CE. The main difference between Maldivian mosques and Indian temples are the absence of human and animal representations. Apart from that, these monuments share similar external decorative technique laage, an exterior decorative element depicted in doorways, pilasters, and mouldings. Gujarati architecture was also important in the genesis and the development of the Swahili houses and mosques, notably in the plans and interior decoration from the 13<sup>th</sup> to the 14<sup>th</sup> centuries in Kilwa and Mogadishu (Lambourn, 1998 and Pradines, 2022: 232-238). White marble tomb stones were also exported from Gujarat to Mogadishu, Kilwa and the Maldives. Indian Gujarati influences are visible in the 16<sup>th</sup> and 17<sup>th</sup> centuries Maldivian mosques decoration with very delicate sculptures of especially with the mosque lamp and chain design (Figure 22) (Fattal, 1960: pl. 17). Despite Indian influences, the use of sea coral was known on the Swahili coast and in the Maldives before the introduction of a Gujarati repertoire and style. Moreover, there is no recorded use of coral stone in Gujarat (Patel, 2004) and, according to Lambourn, the marble stone quarries were located 200 km far away from the coast (Lambourn, 2006: 4-9). Finally, the Maldivian Mosques have very little in common with the Malabar or Kerala buildings in South India (Shokoohy, 2013: 137-266; Shokoohy, 2018: 314-317), except perhaps some influences on the coffered ceiling and turned woodwork. Both Maldives and Kerala might have been influenced by the stone mosques of Indonesia such as Selo Masjid in Yogyakarta (Shokoohy, 2018: 332-337; Kuria, and Pearson, 2018). The Malabar mosques convey a sense of continuity with Hindu temples and accommodation to local preferences like in the Maldives with Buddhist temples (Prange, 2018: 341-343).

## CONCLUSION

First, it is important to be aware of the frequent confusion in the vocabulary used by archaeologists and architects to describe Indian Ocean architecture. Most of the time “coral stone” refers to coral limestone, and not the fresh sea coral (madrepores and Porites). It was very important for me to create a clear differentiation of the building material used and very specific to the Indian Ocean context: a marine coral collected at low tide in a lagoon or dragged from the great reef barrier. This marine coral is not to be confused with the coral limestone from the mainland.



*Figure-22:* Mosque lamp and chain design in the Maldives from Indian Gujarati influences sculptures.  
Source: P. Pradines

Coral architecture is frequently associated to the medieval period in the Indian Ocean. However, this architecture is much older and dates from the Antiquity period. As we demonstrated in this article, marine coral architecture originated from an area between India and Indonesia. The Maldives and Sri Lanka seem to be the epicentres of this technique. Sri Lanka was at the confluence of different cultures and people using complex stone architecture: Romans coming from the Red Sea, Sasanians coming from the Gulf, Indians coming from the Deccan. These people brought with them their ancient knowledge on masonry techniques. Buddhism was introduced to the Maldives from Sri Lanka around 200 BC. Because of the lack of building material, it is most probable that Maldivians started to use sea coral to build their temples around this period. Sri Lanka and the Maldives had a strong impact in the genesis of coral architecture between 250 BC and 600 AD. Later the diffusion of sea coral architecture in the Western Indian Ocean seems to be connected to the Abbasids mariners and Muslim travellers during the 9<sup>th</sup> century, as well as its globalisation under the Buwayhids and the Fatimids between the 11<sup>th</sup> and 12<sup>th</sup> century and closely related to a rise in Muslim trading networks in the Indian Ocean.

This paper is just the beginning of a large-scale investigation on coral stone architecture in the Indian Ocean. In the future, two phenomena need to be identified to understand this maritime architecture. First, the history of this technology must be determined by pinpointing the places of origin of this architecture with the location of the oldest buildings built with sea coral in the Indian Ocean. Second, the diffusion of this technique across the Indian Ocean needs to be clearly traced, if it is possible, as there were a lot of multilateral technological exchanges around sea coral as a raw material. For me, it is not an Asian technology nor an African

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technology, but an Indian Ocean material culture.

As a final note, the coral buildings are “stuck” in between what I call, the “global warming dilemma”. First, the building material, the coral, is now protected in marine parks, precisely because of global warming and corals in some places are considered as a species in extinction. It is very difficult to do some conservation works on historical monuments without taking new corals from lagoons, most of the time with the WMF conservation team, we tried to reuse old blocks, but sometimes we needed special agreements from local authorities to get some new corals to restore ancient monuments. It is what I call the “dilemma between nature and culture”. Second point, the coral mosques are under threat of rising sea levels and coastal erosion, if we do nothing, many sites and monuments will disappear under the water, or they will be destroyed by coastline erosion. It is the reason why with my colleagues, heritage architects

from the AKTC, the WMF and UNESCO, we are fighting to protect these monuments and Indian Ocean maritime heritage, from East Africa to the Maldives.

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