CHRONICLE OF CORAL HERITAGE: THE PAST, PRESENT, AND FUTURE OF BOHOLANO BUILT STONE HERITAGE

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1. Introduction

The use of limestone, particularly coral stone, has been the cornerstone of Boholano built heritage. Boholano churches, belfries, defensive fortifications, and some private residences from the Spanish colonial period have been built with this material to build structures that have lasted for hundreds of years. Quarried from shores and coastal regions, coral stones are a finite resource generated by harvesting the skeletal remains of living organisms called coral polyps. It is a sturdy material, capable of withstanding forces up to 20 MPa and has great workability [1]. Coral stones have a multitude of applications: they can be ground into fine powder to create lime mortar, recycled into rubble as aggregates, cut into rectangular blocks for wall construction, laid out over the ground to build structural foundations, or applied as cladding for decorative finishes. In the past, Boholanos, with the guidance and European aesthetics of the Spaniards, used coral stones to great effect, constructing giant structures that have survived across the centuries until today.

Following the 2013 earthquake, which greatly devastated various immovable cultural properties in Bohol, both government and non-government organizations initiated efforts to restore and preserve Bohol's built heritage. The National Historical Commission of the Philippines (NHCP) [2], together with the National Museum of the Philippines (NMP) [3], began restoration projects using traditional materials and techniques wherever possible. International assistance, such as that from UNESCO and cultural agencies from other countries, also supported the recovery efforts [4]. Furthermore, various heritage groups, the ecclesiastical sector, and other private enterprises have started to play more active roles in raising awareness and funds for heritage conservation. Initiatives such as documentation, educational campaigns, and training workshops for conservation techniques are helping to build a sustainable approach to heritage management. Coupled with Bohol's recent designation as a UNESCO Global Geopark in 2023, now more than ever, Boholanos have called out for the conservation of their cultural heritage [5].

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2. The Province of Bohol

Bohol is an island province located in Region VII, Central Visayas region of the Philippines along with Cebu, Negros Oriental, and Siquijor. It has 47 municipalities with Tagbilaran City serving as its provincial capital [6]. Bohol's inhabitants number around 1.4 million people (2020 census) living over a land area of 4,800 km^2. In 2023, it was designated as the first Philippine UNESCO Global Geopark, sparking the need to conserve its cultural, scientific, historical, and geological heritage. At present, Bohol has a multitude of cultural properties recognized locally, nationally, and internationally. Of these, 23 are known as coral stone structures, 17 of which are churches and 6 are watchtowers that also doubled as belfries (Figure 1 and 2). Most of these buildings were erected during the Spanish colonial period [7].

Figure 1. Map of Bohol (Source: GADM; Author).

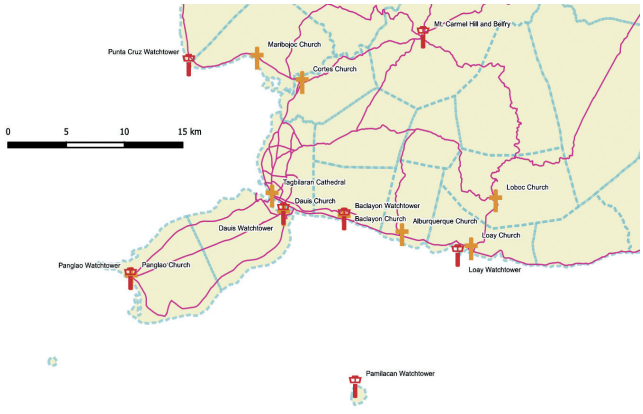

Figure 2. Map of Southwestern Bohol (Source: GADM; Author).

2.1. The Society of Jesus

Formal Christianization of Bohol happened during the arrival of two Jesuits in Baclayon, November 1596, following a request made by Catalina de Bolaños on behalf of her son, Pedro de Gamboa, then a minor and the *encomendero* (trustee of the Spanish crown to levy natives for labor) of the island at that time. Boholano architecture was already a flourishing practice in this period, as evidenced by the archaeological remains of huge wooden posts along both sides of the channel between Panglao and Bohol dated around the 1560s, which suggest Boholano's mastery in erecting sturdy hardwood structures prior to Spanish contact [8].

The Society of Jesus, a religious order (Jesuits), utilized this expertise as they ministered to Bohol's spiritual needs from the start of the 17th century until around the middle of the 18th century. Over that period, they managed to earn the trust of the local inhabitants and converted them to the Catholic faith. Using Boholanos as a labor force, they built residences, chapels, churches, and carried out various infrastructure work all over the island. Despite being initially mistrusted due to being wrongly associated with tribute-collectors, after years of missionary work and the public eschewing of material wealth, the Society of Jesus managed to overturn the Boholano people's initial distrust and indifference [9]. As part of their activities, they chartered villages and settlements for convenience as they attended to their flock. Among the villages they created, and which went on to become Bohol's municipalities are: Loboc, Baclayon, Dauis, Maribojoc, San Miguel de Hagna (now Jagna), Talibon, Ynabanga (now Inabanga), San Jose de Tagbilaran (now Tagbilaran City), and Santisima Trinidad (now Loay) [10]. It was in these villages that the first of Bohol's churches and chapels were built using timber, bamboo, and *nipa* (palm-like trees that grow in riverbanks), sourced locally from the area.

However, by the start of the 18th century, external threats and natural disasters had forced the Jesuits into eschewing wooden architecture and adapting stone masonry. Periodic earthquakes and annual typhoons visited the country, greatly devastating the island nation. Without special building techniques such as *Tabique Pampango* walls (wattle and daub interwoven frames of wood and bamboo slabs covering a mixture of lime, sand, and clay), these wooden structures were no match against natural calamities. Coupled with outbreaks of fire born of accidents or deliberate arson from Moro piratical raids, the Jesuits were left with no choice but to rebuild their churches in stone. Among the enduring stone structures they built are Baclayon Church (completed in 1727), and Loboc Church (built in 1734). The earliest known stone building attributed to them is the core of the three-story convent adjacent to Loboc Church, believed to have been constructed around the 1670s [11]. The edifices seen today are the same structures, built centuries earlier, with some modifications, adaptations, and reconstructions to better suit modern life.

2.2. The Order of Augustinian Recollects

By the 1760s, political and ecclesiastical intrigues in Europe affecting the Society of Jesus started brewing. In 1768, a royal decree written by King Charles III of Spain arrived in the Philippines. The Society of Jesus was suppressed and all the Jesuits currently undertaking missionary activities were recalled back to Rome. They were removed from most of Western Europe and their respective colonies, including the Philippine islands under Spanish dominion [12]. The spiritual role that the Jesuits left behind was then taken over by the Order of Augustinian Recollects.

The Augustinian Recollects' time was fraught with constant Moro raids – so much so that the first stone structures the Recollects built were defensive in nature. Stone

watchtowers, which also doubled as church belfries, were built in Loboc (1770s), Dauis (1774), Baclayon (1777), and Maribojoc (1796). By the end of the 18th century, several towns such as Loon and Dimiao were fortified with stone walls. The need for early warning systems was so great during this period that watchtowers continued to be built well into the 19th century, including those in Balilihan (1844), Panglao (1851), and Pamilacan island (undated, but believed to have been built in the 19th century).

As the 19th century began, the Recollects also started rebuilding wooden chapels as proper stone edifices. Using stone, they rebuilt Dimiao Church (1800-1815), Tagbilaran (c.1800 – c.1850), Jagna (1810-1867), Loon (façade from the earlier church begun c.1812, rest of the church 1855-1864), Loay (1822), Inabanga (1830s), Maribojoc (1852-1872), Talibón (1850s – late 1860s), and Cortes (late 1880s-1892). They even added porticoes to Jesuit-built stone churches, to protect parishioners from sun and rain. After the Recollects left in 1989 following the Philippine Revolution, portions of some churches were only completed in the early 20th century upon the initiative of the secular clergy, including Dauis (1863-1923), Alburquerque (1885-1920s), Guindulman (1880s-1930s and later), and Panglao (c.1894-1924).

3. Boholano built stone heritage

Heavily influenced by European artistic standards during the height of the Renaissance, the dominant architectural style of Bohol's built heritage is Earthquake Baroque, a regional adaptation of the European Baroque style suited to the earthquake-prone areas of the Philippine archipelago. This style is marked by dramatic contrasts of light and shadow, elaborate ornamentation, curved forms, broad and low structures, domes, and interiors designed to evoke emotion. These are complemented by thick exterior walls, buttresses, and minimalist yet robust facades engineered for resilience against natural disasters. Such architectural elements are prominently seen in early colonial Jesuit-built churches across Bohol, including those in Baclayon (Figure 3A), Loboc, and Dauis (Figure 3B).

Figure 3. Jesuit-built Bohol Churches. (A) Baclayon Church; (B) Dauis Church (Source: Wikipedia).

Later churches, such as those built in the 18th and 19th centuries under the Recollects emerged with a shift in architectural expression. While they retained traces of Earthquake Baroque, these newer structures incorporated a blend of stylistic

influences reflecting the then-popular eclectic movement. This trend involved the revival of historic architectural styles, including Gothic Revival featuring pointed arches and decorative Gothic elements, and Neoclassicism, which brought back Greek and Roman design motifs. Churches in towns such as Talibon (Figure 4A), Valencia, Loon, Panglao, Albuquerque, Tagbilaran (Figure 4B), Maribojoc, Loay, Tubigon, Cortes, and Dimiao reflect this architectural fusion.

Figure 4. Recollects-built Bohol Churches. (A) Talibon Cathedral; (B) Tagbilaran Cathedral (Source: Wikipedia).

3.1. Construction

The construction of these heritage structures was no simple endeavor. While there are no records of the bureaucratic system involved during the construction of churches and chapels by the Jesuits, the Recollects managed to import a civic system needing the formal permission of the bishop to conduct infrastructure work. Several of these buildings, particularly those built at the beginning of the 19th century onwards, were documented to have undergone several administrative processes to ensure the quality and the completion of the project. To start with, the parish priest was required to submit an architectural plan, an itemized budget and a statement showing how much money the parish had. Generally, the person designated to manage the project had to prepare the architectural plan and the budget while the clergy handled the parish funds. For most of the island, the management of the project seems to have been the responsibility of the local *maestros de obras*, foremen who also directed the construction work and received regular wages. Additionally, another permit was needed from the office of civil administration to obtain logs from the forest.

Funding came from several sources, primarily from direct donations given by the town's principal citizens. Basic building materials such as gravel and sand, stones roughly cut into rectangular blocks, timber, and other necessities were sourced from the local citizens. Another portion came from a sanctorum tax, money collected from the faithful on certain feast days, and *arancel*, stole fees the parish priest received for administering sacraments such as baptisms, weddings, and funerals. If the funding fell short, the parish could ask neighboring churches for money with the bishop's approval and they could also petition the Recollects mother house in Manila for extra funds; but more often than not, loans were extended. Another notable fund also came from the community coffers, *cajas de comunidad*, but it was only introduced later in Bohol at the end of the 18th century [13].

However, the system was not without criticism. Since the time of the Jesuits, a forced labor system, *polo y servicio*, was in effect, wherein the laborers, *polistas*, were forced to work without compensation as an alternative to paying their taxes. Numerous historical accounts from various towns and *barangays* (a smaller administrative district than towns) of Bohol unanimously agreed that the construction of the churches and convents involved indentured labor. Several documents explicitly narrated the use of harsh and forced labor, with "every male person required to attend mass and take with them a quarry of stones or else be imprisoned in the dungeon" [14]. Other accounts also stated the corruption of these Spanish friars, sometimes requisitioning the materials gained from the Boholano people to use for their own gain.

3.2. Structural configuration of the buildings

The general construction method of Boholano heritage architecture was *mamposteria*. The method involved the use of Spanish stonework made from coral stones collected from seashores cut into rectangular shapes and then cemented together using a lime mortar. It is speculated that the mortar was made from either burned coral, egg whites, and occasionally molasses or tree resin, or a mixture of two or more, which was then used to encase a compressed mixture of stone rubble and soil. While no definite proof of the usage of these materials exists in published literature, some churches like the Baclayon church claimed to have used millions of egg whites as cement for the entire structure [15]. Underneath the soil, the foundation of the buildings is made from a layer of similarly cut coral stones overlain atop bare ground and serves as the bedding for the entire *mamposteria* structure.

One peculiar aspect of Boholano *mamposteria* is the lack of a capping component, such as some form of cover or a capping beam at the top, which means that the walls and columns of Boholano *mamposteria* are open to the elements above. Instead, it is held together by roof trusses with the roof its only defense against rain or foul weather (Figure 5). Speculation from the engineers and architects working on the reconstruction of the destroyed churches after the 2013 Bohol earthquake attribute this open section as being one of the main factors which greatly contributed to their collapse.

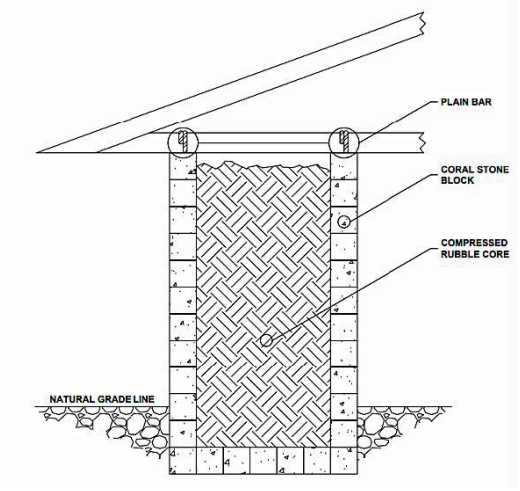

Figure 5. Cross-section of Boholano mamposteria (Source: Author).

In churches, the interior of the structure is supported by *harigues* (columns) spaced equally along the nave to support the central dome and the roof. Usually, the *harigues* are also *mamposteria* but some churches like Alburquerque church have managed to retain their wooden *harigues* over the years (Figure 6). However, other scholars have pointed out that these *mamposteria harigues* might have just covered the older, prior lighter wooden *harigues* underneath.

Figure 6. Alburquerque Church Interior (Source: Author).

This structural configuration, with roofs and domes supported by *mamposteria*, is effective at bearing gravity loads that act through the walls and columns, and into the foundation, but is particularly vulnerable to lateral forces and out-of-plane shear stress. To address this, buttresses built from the same materials were added to the exterior walls at spaced intervals, strengthening the structure against seismic activity (Figure 7). Structures without these reinforcements, such as watchtowers that also served as belfries, were more prone to seismic damage. Conversely, buildings designed with wide, low profiles like the Punta Cruz Watchtower in Maribojoc can easily withstand tremors, though some portions of the coral walls have collapsed.

Figure 7. Alburquerque Church, right side (Source: Author).

4. Visible degradation

Despite centuries of durability and careful conservation, even historic structures are not immune to damage and degradation. Even now, Boholano heritage buildings show visible deterioration. We must remind ourselves that cultural heritage, if not managed properly, will collapse under the weight of time and calamity. Natural disasters are unavoidable, and while we can mitigate environmental and human factors, conscious preservation strategies and community involvement are still needed to protect priceless cultural assets. In Bohol, the mounting damage on its built heritage is culminating, and one day, may prove too much for the structures to handle, and they will consequently disappear. To combat this, issues must be resolved at the roots, the first step in this process being identification, in other words, an inventory must be compiled of the damage these structures have sustained throughout their lifetime.

4.1. Vegetal growth

Vegetal growth is one of the most visible and direct threats to coral masonry conservation in Bohol. The porous surface of the coral stone allows it to retain moisture, which creates ideal conditions for vegetal growth [16]. Mosses [17], fungi [18], and lichen [19] are known to enhance physical and chemical weathering of rocks and minerals based on field and experimental studies, secreting organic acids that chemically interact with the calcium carbonate composition of coral stones, accelerating dissolution and erosion. Additionally, these biological growths also encourage the facilitation of an environment conducive to the growth of vascular plants [20]. The roots of these invasive species penetrate the minute crevices and pores of the coral stone,

and as their roots grow and expand, they exert pressure on the stone matrix, leading to cracking, displacement, and gradual structural weakening [21]. This dual mechanical and chemical attack makes unmanaged vegetation a significant and ongoing threat to coral masonry structures.

A huge portion of Boholano built stone heritage suffers from uncontrolled vegetal growth. A brief look around these buildings showcases the extensive growth of mosses, algae, and lichens. Dark greenish patches are smeared across these ancient stone blocks, damaging the aesthetic appearance and the substrates of the coral stones (Figure 8).

Figure 8. Vegetal growth along coral stone structures. (A) Punta Cruz Maribojoc watchtower; (B) Alburquerque Church (Source: Author).

4.2. Animal and insect infestation

Animals, ranging from the microscopic to the visible, pose a persistent danger to Boholano coral stone structures. Insects, birds, and small mammals such as rodents may burrow, scratch, or nest within cavities and the dark, cool shade, underneath piles of coral stones, creating physical damage over time. Ants, for example, use the porous surfaces of coral stone as hidden pathways in search for food. A study also suggests that ants may have a hand in calcium carbonate alteration [22]. Arachnids and other insects sometimes hide inside some particularly large holes, laying their eggs and nursing their young. Usually, they also die within these cavities, inadvertently staining the stone and creating chemical reactions that may damage it. Others, like termites, do so indirectly, by nesting in adjacent wooden supports that can compromise the overall structure, allowing moisture to seep into the stone masonry and making it more susceptible to further biological growth and decay. Despite no extensive literature having been published to explore the damage caused by these critters and crawlers on harvested coral stones, it is still an undeniable fact that insect and animal infestations exist within Boholano built stone heritage.

Additionally, avians such as crows and pigeons are commonly found nesting above the rafters and on the ledges of historic buildings. Their droppings, guano, are highly acidic and can erode coral stone surfaces, leaving behind unsightly stains and weakening the stone chemically [23]. These biological residues also attract microorganisms that further deteriorate the stone. One watchtower in Maribojoc has a bat nesting on the structure's rafters. As the structural integrity of the second floor has been compromised, cleaning the upper section was deemed unsafe.

A particular problem of Maribojoc Punta Cruz Watchtower is the colony of bats taking up residence underneath the rafters along the upper section of the trusses (Figure 9). While the wood itself currently shows no signs of weakness, the constant weight and movement of these animals may gradually loosen connections and accelerate wear on the wooden members and, as a result, might loosen tile attachments or compromise the roof's waterproofing integrity. Furthermore, the acidic nature of bat guano gradually erodes limestone surfaces, erasing details and weakening the lime mortar over time [24]. These factors pose genuine concerns that while the roof currently remains stable, the ongoing bat infestation poses risks that could affect its long-term durability if left unaddressed.

Figure 9. Bat roost above the rafters of Punta Cruz Maribojoc watchtower (Source: Author).

4.3. Vandalism

Vandalism has always been an age-old problem [25]. It is a complex psychological issue rooted in various factors such as cognitive dissonance (moral constraints of propriety and the convenience of littering) [26], sadism (i.e. destroying things for pleasure) [27], perceived lack of punitive consequences [28], and low cultural and educational awareness [29], with several studies suggesting that younger demographics, a portion of the population more likely to have a combination of these traits, are therefore more likely

to commit vandalism. Indeed, a thorough inspection of several Boholano built heritage shows extensive vandalism attributed to youthful indiscretion. Childish or thoughtless messages such as names, distasteful commentary, or random years and dates of inscription dot the walls and corners of the stone structures.

4.4 Natural hazards

The Philippines is subject to several natural hazards, primarily typhoons and earthquakes. As a country situated in the Pacific Ring of Fire and just right above the equator, the Philippines experience periodic seismic activity, and over an estimated twenty tropical cyclones enter the Philippine Area of Responsibility (PAR) annually, with nine to ten of them making landfall [30]. Disasters caused by Typhoon Yolanda (international name Haiyan, 2013), M7.2 Bohol earthquake (2013), Typhoon Odette (international name Rai; 2021), with their toll of thousands of victims, have also devastated the Philippine archipelago, costing them billions of pesos in property damage. These disasters, moreover, have not only disrupted their present life and cut off a lot of people's futures, it has also damaged the nation's past.

In Bohol, the recent 2013 earthquake dealt a catastrophic blow to their built heritage. Among the most notable losses was the Baclayon Church, whose entire façade collapsed and, in addition, suffered extensive internal damage (Figure 10A). Likewise, Loboc Church, situated near the Loboc River, crumbled into ruins, losing its bell tower and significant portions of its structure (Figure 10C). Loon Church, considered the largest and grandest in Bohol, was razed to the ground leaving behind little more than its foundations (Figure 10B).

Figure 10. Damaged coral stone structures of Bohol. (A) Baclayon Church; (B) Loon Church; (C) Loboc Church; (D) Maribojoc Church (Source: Wikipedia).

In addition to churches, several heritage watchtowers, convents, and ancestral houses were also damaged or destroyed. The Punta Cruz Watchtower in Maribojoc, which had stood sentinel over the sea since the 18th century, sustained major structural damage (Figure 11). Maribojoc Church, too, was flattened (Figure 10D). Even towns further from the epicenter, like Dauis and Panglao, reported structural cracks and partial collapses in their heritage churches.

Figure 11. Damaged Punta Cruz Maribojoc watchtower (Source: Wikipedia).

5. Conclusion

The churches of Bohol stand as enduring testaments to centuries of Filipino faith, artistry, and resilience. Scattered across the island, these religious structures – some of which date back to the Spanish colonial period – are not only places of worship but also vital cultural landmarks. Built primarily using coral stone, limestone, and hardwood, they reflect a fusion of European baroque architectural principles and native building techniques, giving rise to what is known as “Earthquake Baroque” architecture. But despite centuries of endurance, even they are not immune to time and degradation. This is a poignant reminder of the vulnerability of cultural heritage in the face of both time and calamity. While natural disasters may be unavoidable, the ongoing damage due to environmental and human factors can be mitigated through conscious preservation strategies and community involvement.

Conserving coral stone structures goes beyond simple upkeep – it is a pledge to preserve a living testament of craftsmanship, culture, and community heritage. Even the most basic preventive measures should be carried out regularly, and not only in response to major damage or disasters.

Table 1 shows the factors identified within this paper, the alterations and degradation they have caused and several simple mitigation strategies that can temporarily prevent further damage. Simple, low-cost strategies – such as gentle

surface cleaning, raising public awareness, meticulous scraping of biological growth, limewashing, conducting periodic assessments, setting up physical barriers and warning signs to deter over-eager tourists [28], installing protective nets against bats and other avians, and moisture management – can be highly effective. More advanced, case-specific interventions may involve pollution management [31], ultrasonic acoustics [32], chemical-based treatments, applying compatible protective coatings [33], or installing secondary reversible structural systems. Conservation is a case-by-case problem, and while novel approaches are welcome, simple but well-chosen actions are sufficient to extend the life and integrity of the coral stone.

Table 1. Effects of various degradation factors and mitigation strategies

Factors	Alterations (Reversible)	Degradation (Irreversible)	Mitigation Strategies
Vegetal Growth	Moss/lichen stains, vascular plant roots intrusion	Deep root penetration leading to cracking and disintegration of coral blocks	Regular cleaning, limewashing, careful surface scraping, moisture management
Animal & Insect Infestation	Staining, minor cavities, surface etching, bat guano dissolution of stone surfaces	Structural weakening of rafters, mortar erosion, roof instability	Protective nets, pest control, routine inspection, simple cleaning and upkeep
Vandalism	Surface scratches, inscriptions, minor defacement	Loss of historic fabric, erosion of symbolic/cultural value	Educational campaigns, signages, constant surveillance, community involvement, coatings of compatible paints
Natural Hazards	Hairline cracks, partial collapses	Total collapse of facades, towers, or entire churches	Seismic retrofitting using secondary reversible structural systems, disaster preparedness

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Summary

Bohol is recognized as a UNESCO Global Park, renowned for its single, unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education and sustainable development. In accordance with UNESCO objectives, this paper explores the rich cultural heritage of Bohol that harmonizes and exemplifies fundamental Filipino traits

such as beauty, artistry, faith, devotion, and hospitality. Spanish colonial era coral stone structures are one of these cultural heritages, symbolizing Boholano's enduring Christian legacy. Built hundreds of years ago, these structures are made from local materials, coral stones quarried from the shores, and timber harvested from the surrounding forests, incorporating European architectural philosophy and labored by Boholano sweat and blood. However, despite careful preservation, even these ancient stone edifices are not immune to time. This paper explores the current state of degradation these structures are experiencing and offers intervention strategies to minimize them.

Riassunto

Bohol è riconosciuta come UNESCO Global Park, noto per i suoi ambiti geografici unitari, nei quali siti e paesaggi di rilevanza geologica internazionale sono gestiti secondo un approccio olistico che integra tutela, educazione e sviluppo sostenibile. In linea con gli obiettivi dell'UNESCO, il presente contributo esplora il ricco patrimonio culturale di Bohol, che armonizza ed esemplifica tratti fondamentali dell'identità filippina quali bellezza, senso artistico, fede, devozione e ospitalità. Tra queste espressioni culturali rientrano le strutture in pietra corallina risalenti al periodo coloniale spagnolo, che rappresentano una testimonianza duratura dell'eredità cristiana della comunità boholana. Realizzati centinaia di anni fa, questi edifici sono costruiti con materiali locali, in particolare pietra corallina estratta dalle coste e legname proveniente dalle foreste circostanti, e integrano principi architettonici europei con il lavoro e il sacrificio delle popolazioni locali. Tuttavia, nonostante le pratiche di conservazione attuate nel tempo, anche questi antichi manufatti lapidei non sono immuni dagli effetti del degrado indotto dal trascorrere del tempo. Il contributo analizza lo stato attuale di deterioramento che interessa tali strutture e propone strategie di intervento finalizzate a ridurne l'impatto, con l'obiettivo di garantire la conservazione e la trasmissione futura del patrimonio costruito in pietra di Bohol.