Malta
Tourism
Observatory

ON THE EDGE

Edited by Godfrey Baldacchino

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Foreword

It is with pleasure that I am penning this foreword to this useful and interesting publication of the Malta Tourism Observatory.

I find the title, "On the Edge", very descriptive and symbolic as islands and their coastlines are very obviously landmasses which are literally, on the edge. Being on the edge does not detract from the attractiveness and pull which islands exert on visitors: rather it is because of the degree of separation from the mainland and the sense of isolation which renders such locations intriguing and attractive to the inquisitive mind.

Malta and its Islands comprise a small but compact archipelago located in the Central Mediterranean. It is located peripherally at the boundary between Europe and North Africa, although its coordinates can also be deemed to be quite central owing to its providential placing on the major shipping routes criss-crossing the Mediterranean, the sea between the land and the cradle of many a world-changing civilisation.

This precisely describes the paradox that is Malta: a rare sovereign island state in a Mediterranean full of islands most of which form part of larger countries and a peripherally located outcrop of sedimentary limestone which also lies at the centre of the Middle Sea.

When undertaking the challenge of producing this publication, the editor, Professor Godfrey Baldacchino, identified an excellent choice of contributors and topics to adequately cover the complexity that defines Malta and its Islands. The Maltese Islands are thus described in terms of their geology and the islands, islets and smaller rocks comprising them. The coastal dimension is described from the perspective of caves, arches, ports and cliffs while human-made features such as coastal towers, lighthouses and rock-carved salt-pans are also given due prominence.

The choice and mix of topics reflect the reality comprising the Maltese archipelago: a territory of numerous larger and smaller islands and islets with a varied, indented coastline, parts of which still display elements of wild nature and others which feature a wide panoply of human interventions which have had significance over the millenary history of Malta.

The link to tourism is direct and obvious. Island tourism is mostly coastal tourism and the edges of islands constitute those elements which are mostly sought after by tourists. There is no doubt that a publication of this nature and quality can only help the practitioner, planner, investor, traveller, student, resident and visitor to achieve a greater understanding and appreciation of that which makes the Maltese Islands truly unique - an increasingly popular destination for discerning visitors from all over the world.

Hon Ian Borg
Deputy Prime Minister and Minister for Foreign Affairs and Tourism

Introduction

The Malta Tourism Observatory continues to make great strides in the field of extending and expanding the body of knowledge available to a wide range of users interested in understanding and contributing to the development of tourism in Malta.

This is in line with the Government's stated direction and the Malta Tourism Authority's strategic objectives of shifting the country's tourism increasingly towards a quality focused, sustainable set of visitor flows which maximise economic contributions whilst preserving and enhancing those tangible and intangible elements which make the Malta brand the powerful proposition that it has become.

This booklet is the first of what is planned to be an ever-expanding set of publications covering a very wide range of themes which influence or are influenced by the tourism sector. Each booklet will be addressed towards a specific discipline, area of interest or audience and collectively, the growing number of issues will help enrich the Maltese tourism oeuvre with a broader set of reference sources to lead to a more informed debate and discussion on the subject today and in the future.

Carlo Micallef
Chair, Malta Tourism Observatory

About this Series

One of the major roles of the Malta Tourism Observatory is to act as a catalyst for the generation and dissemination of knowledge which is of relevance for the broader understanding of the tourism phenomenon and its interaction with the wider elements comprising the destination.

Following the publishing of the first edition of Malta Tourism Insights in 2023, the decision was taken to develop the Malta Tourism Insights brand into two types of publication: an annual publication consisting of a review of performance, situation analysis of the identified tourism sustainability indicators and Malta Tourism Strategy updates and occasional publications by Guest Editors focusing on specific themes considered to be of interest from the tourism perspective.

This publication, edited by Professor Godfrey Baldacchino, is the first in the series of occasional publications and, appropriately enough, focuses on islands and coastal characteristics. It consists of a collection of essays by professionals each recognised and respected for their authoritative knowledge and expertise on the wide spectrum of aspects targeted by the publication. Collectively, they have contributed to this collection aptly titled, “On the Edge”.

The Malta Tourism Observatory remains committed to foster a greater understanding of all the elements which combine to make the understanding of tourism more widespread. It does this in the belief that, armed with as much information and knowledge as possible, Malta increasingly goes down the path which maximises the Tourism Industry’s contribution. Maximisation can only be achieved by simultaneously helping to sustain and preserve all that which makes the Maltese Islands unique and diverse from the rest of the world.

Leslie Vella
Managing Director, Malta Tourism Observatory and Series Editor

The walled peninsular town of Senglea, flanked by French Creek and Dockyard Creek.

Editorial Introduction:

Beyond Beaches

Godfrey Baldacchino

We think of and about Mediterranean islands and tourism, and invariably our thoughts wander playfully to beaches, and all the fun, frolic, entertainment and sport activities that take place in those privileged, interstitial spaces. But, for destinations like Malta, tourism has never been all, or even mainly, about beaches. These are too few and too small: the longest, Għadira (or Mellieħa) Bay, is 700 metres long. And, as the locals know full well, most places that are suitable for swimming in the Maltese Islands are rocky rather than sandy, and deep rather than shallow, which departs from island postcard expectations.

ON THE EDGE is a publication that showcases the Maltese coastline, but it goes beyond the obvious and explores instead a series of features – some natural, some cultural, some combined – that deliberately exclude beaches along the country's 270+ km-long sea-land interface. The inclusion of and focus on these features in this collection speaks to the diversity of the edge of the Maltese archipelago, an impressive characteristic for what is, in terms of land area, the tenth smallest country in the world.

The features under review are not all-inclusive; but they should be enough to highlight the incredible diversity of the natural and cultural coastline of the Maltese islands. We should also remind ourselves that every part of the edge of the country is never too far away from anywhere in the Maltese archipelago.

Here are the eight features that comprise this publication:

Rocks. The Maltese archipelago boasts an impressive range of rock formations and landforms that represent the tension of forces at the edge, between land and sea. Here, we review the five components of rock strata, of which the marine sedimentary structure is primarily composed, from the oldest to the youngest. We also describe nine types of coastal geomorphological landforms.

Islets. There may be just three populated islands – Malta, Gozo and Comino – but the Maltese archipelago comes with around three dozen additional, named islands, islets and rocks. Some of these rocky perturbations are large enough to come with their own histories, while the smaller members are caught in a keen aquatic embrace. Their collective tribulations are testimony to the dynamic 'land sea' equation. A judicious selection of sixteen of these islets and rocks is reviewed here.

Caves and Arches. Limestone can be worn away by the combined action of wind, water, rain, salt and temperature changes over time. As a result, some interesting geological features materialise. Best known in Malta is Blue Grotto; while the Azure Window was the 'go to' feature and 'must'

photo backdrop in Dwejra, Gozo, until it crashed spectacularly into the sea in March 2017. Other candidates vie for attention and selfie opportunities.

Ports. Malta's history is deeply entangled into the unique features of Grand Harbour, a coveted deep water, all-weather, sheltered harbour alongside Valletta: quite unique for a small island in the central Mediterranean. This space is now a densely multifunctional arena, delivering commercial, residential, recreational and industrial facilities. Three additional areas offer port services in the Maltese Islands. Two are Ċirkewwa (Malta) and Mġarr (Gozo), the respective end and berthing points of the ferry service across the 8km Gozo Channel, and, in the case of Mġarr, much more besides, as the only gateway to Gozo. The third is Marsaxlokk Bay in the south-east, which has taken on the overflow from Valletta, and is now dominated by the Malta Freeport Terminal on one side and the Delimara Power Station on the other, with the communities of Marsaxlokk and Birżebbuġa nudged in between.

Cliffs. Geologically, the islands of Malta and, to a lesser extent, Gozo slope from west to east. Most of the cliffs lie on the west, while most of the low-lying areas and bays and ports lie on the east and south. The cliffs close to Dingli (in Malta) and Munxar, Sannat and San Lawrenz (in Gozo) are the domains of an impressive variety of flora and fauna. Spectacular vistas abound.

Lighthouses. Two lighthouses practically represent the extreme ends of the Maltese archipelago: Delimara to the South-East, not far from Marsaxlokk, in Malta; and Ta' Ġurdan to the North-West; not far from Għasri, in Gozo. They dominate their respective landscapes, in contrast to their smaller counterparts on either side of the entrance to Grand Harbour: the only other lighthouses in the Maltese Islands. The original functions of the Delimara and Ta' Ġurdan structures have been overtaken by navigation technology; they now serve rather different purposes from those originally intended.

Coastal Towers. Ten towers and watchtowers built during the rule of Italian Grandmaster Giovanni Lascaris survive; as do eight towers from the 13 originally built on the initiative of Spanish Grandmaster Martin De Redin. And four of the six towers commissioned by French Grandmaster Alof de Wignacourt also survive. Most of these structures are coastal, protecting the coast from invasion or serving to relay information and early warning signals of the arrival or landing of any hostile forces. These survivors also betray the ravages of time; and their function has completely morphed away from the provision of security or defence. Some have justified their existence and operation as museums, research facilities, restaurants, even police stations.

Salt Pans. This is a rare industrial activity for Malta, and the only one that takes place on the rocky coastline, tracing its history back over centuries. The practice of extracting salt from the surrounding sea has been in decline for decades, but tourism and a revival in the appreciation of things local and traditional has given the 'industry' a new lease of life. Three salt pan complexes remain in working order: the industrial site at (the aptly called) Salina Bay, l/o Burmarrad; the Xwejni salt pans near Marsalforn, in Gozo; and the Delimara ones in south-east Malta.

In this rather original manner, this booklet seeks to present the signature of the Maltese Islands' assorted and mottled engagement with the sea: forceful, daring, promising, sustaining. Clearly, island life in Malta is more than a beach.

Rocks

Ritienne Gauci

Ta' Marija Cave, popular with kayakers.

Rocks: Envoys of natural transformation

Though we often think of rocks as static and immutable, every single geological record along the Maltese coast tells a story of dynamic transformation. Rocks are far from inert; they are the visible manifestation of millions of years of natural forces: marine sedimentation, tectonic upheavals, impactful waves, relentless winds, and the slow imperceptible work of weathering. The rocky coasts of the Maltese Islands are a testament to this continuous evolution, capturing the eternal struggle between rock resistance, erosion and deposition. To walk along the Maltese limestone shores is to witness geology as a living record, where each cliff face, boulder, pebble or sand grain reflects the intricate geological and geomorphological processes that sculpted the Islands' distinctive coastline.

Coasting the Maltese geology: Five main formations

Despite its modest size, the Maltese coastline boasts a geological diversity that is characterised by a marine-derived sequence of five main sedimentary formations, dating back to the Oligocene and Miocene epoch i.e., around 28 to 7.5 million years ago. These rock units are a mix of limestone, marls, and clays, and represent the islands' complex history of environmental changes in central Mediterranean. Marine deposits were injected with calcium carbonate-rich shells and built into a multi-layered platform that subsequently emerged above sea level by tectonic uplifting forces around 5 to 7 million years ago. When this sedimentary base emerged above sea level, terrestrial deposits of Quaternary age (from 2.5 million years ago) began to accumulate in pockets across the landscape, rapidly infilling caves with fossiliferous deposits, washing out fluvial deposits on the coast as clastic-rich fans or depositing fine debris as aeolian (wind-derived) deposits into dunes.

The marine sedimentary structure is primarily composed (from the oldest to youngest) of five rock strata: Lower Coralline Limestone (LCL), Globigerina Limestone (GL), Blue Clay (BC), Greensand (GS), and Upper Coralline Limestone (UCL). Three of these limestone strata are further subdivided into members based on distinct physical and chemical traits, such as sea-bed fossil content, grain size, colour, and hardness. These characteristics reflect environmental shifts at the time of deposition, including variations in sea level, climate, and biological activity. These five stratigraphic layers have in turn significantly influenced the coastal geomorphology of the Maltese Islands.

The Lower Coralline Limestone (MT: Żonqor or Qawwi ta' Isfel) is the oldest rock formation visible in the Maltese archipelago, dating back to the Oligocene epoch, around 28 million years ago. It constitutes 36% of the Maltese coastal geology. This massive limestone is composed predominantly of bioclastic calcarenite (made from broken shells and other marine life remains) and is characterized by a dense, light grey to brownish hue. Its resistance to erosion makes it the backbone of Malta's most dramatic coastal features, such as the towering sea cliffs along the southwestern coastlines of Malta and Gozo, including Ta' Ċenċ cliffs, which rise 140 metres above sea level. LCL also appears prominently along fault lines on the north-eastern and southern coasts, such as from Madliena Tower to the Dragut Point (Sliema), and along Marsaskala Bay. Tectonics would have played a role in tilting and fracturing the exposed limestone, creating rectilinear fault-derived cliffs and causing sections of the LCL to be exposed at or near the surface on these coasts. Sub-divided into four members (Magħlaq, Attard, Xlendi and Mara), LCL is rich in fossilized remains of ancient marine organisms like coralline algae, bivalves, and echinoids, which reflects a range of marine depositional environments, from shallow lagoons to deeper channels.

Lying atop LCL, is the more erodible Globigerina Limestone (MT: Franka or Soll), which is the most extensively exposed rock formations, spanning the late Oligocene to middle Miocene epochs (23-13 million years ago). Known for its characteristic pale yellow to cream hue, this softer limestone is composed primarily of biomicrites (i.e., fragments of shells or corals embedded in fine-grained sediment) and are rich in Globigerina foraminifera: these are microscopic marine organisms which flourished in the ancient warm seas that once covered the region. With thicknesses varying significantly from 20 metres in some coastal areas to over 200 metres in central Malta, the GL has played a central role in shaping the island's undulating coastal landscapes. It accounts for 35% of the Maltese coastal geology.

Divided into three main members - Lower, Middle, and Upper Globigerina Limestone - each layer reflects subtle differences in composition and depositional environment, largely due to fluctuations in ancient sea levels and sedimentation rates. The Lower (LGL) and Middle (MGL) members are separated by a distinct phosphatic conglomerate, while a similar phosphatic layer divides the Middle and Upper (UGL) members. These layers mark interruptions in sedimentation, likely tied to changes in sea levels or shifts in marine currents. When exposed at sea level, these conglomerate beds are resistant to wave erosion and hence favour the development of shore platforms such as in Sliema, Xwejni (Gozo) and Marsaskala.

MGL is typically finer and less compact, which leads to steeply inclined coastal cliffs where it is exposed, such as along St. Thomas Bay and west of the Delimara Peninsula. Its marl-rich beds, containing fragments rich in phosphate and glauconite minerals, are prone to erosion and mass movement, as seen in areas like Xrobb l-Għaġin. LGL also forms low coastal cliffs that frequently fracture due to the presence of fissures and joints, which are widened and undercut by wave action. These low cliffs are visible along various north-eastern coasts of Malta, including Selmun, St. Paul's Bay, Sliema, Xgħajra, and Marsaskala. Notably, there is growing concern about the rapid deterioration of coastal fortifications, such as at Fort Ricasoli, limits of Kalkara, due to the undercutting of LGL.

The Blue Clay (MT: Tafal) formation dates back to the middle Miocene (13 to 12 million years ago) and is known for its distinct bluish-grey hue and marl-rich composition. Covering around 9% of the Maltese coastal shores, this clay formation typically ranges from 20 to 75 metres in thickness and is composed of alternating layers of dark-grey and pale-grey marls. The BC is relatively impermeable and restricts water infiltration by directing rainwater as surface runoff, making it particularly susceptible to gully erosion and mass movement. As a result, it forms unstable coastal slopes and is prone to landslides, especially along the north-west part of Malta, such as Għajn Tuffieħa Bay and Ġnejna Bay, where marine erosion accelerates the undercutting process and boulder fields develop below the UCL plateaus.

The Greensand (MT: Rina) formation on the coast is mostly found at elevated heights above the Blue Clay and below the UCL and does not dominate the coastal geology of the archipelago. Though relatively thin, GS is a distinctive layer that adds a bright orange to the island's geological palette. This colour comes from glauconite, a greenish mineral rich in iron and potassium, which turns into orange when oxidised. It typically appears as a friable, granular limestone and ranges in thickness from as little as 0.5 metres on Malta to up to 11 metres in the inland area of Gelmus, Gozo, where it is best developed and more prominently exposed. Due to its limited thickness and tendency to be obscured by talus (a pile of loose broken rocks or debris) from the overlying UCL, the Greensand is often visible only in scattered outcrops. It is visible in around 3% of the Maltese coastal shores.

The fifth and final layer is the Upper Coralline Limestone (UCL). This is the youngest rock formation in the Maltese stratigraphic sequence, dating back to the late Miocene (12 to 7.5 million years ago). This formation is present on 16.6% of the Maltese coast and is composed primarily of hard, massive limestone in cream to pale yellow colour. It is rich in fossilized coralline algae, which indicates a shallow, high-energy marine environment during deposition. The UCL is notably thick, ranging from 10 to 170 metres, and forms the highest points on Malta and Gozo. As part of the elevated topography in the northwest of Malta, the UCL forms high plateaus and rugged cliffs and often does not reach sea level. Instead, it is the underlying layers, such as the Blue Clay and Globigerina Limestone, that are exposed to the sea and its actions. This configuration creates a striking landscape, such as at Qammieħ Point on Marfa Ridge or the north-west coast of Majjistral Park, where the UCL caps the highest elevations, while the underlying, more erodible strata shape the coastline by undercutting and fracturing UCL to develop scree slopes, boulder fields and shore platforms at sea level.

The Quaternary deposits along the Maltese coasts are diverse and reflect environmental shifts and geological processes from the Pleistocene to the present day. These deposits, often fragmentary and predominantly of continental origin, appear in locations where erosion has exposed them or where they have accumulated in valley floors and low-lying areas. They unconformably overlie older marine strata from the Oligo-Miocene age and are easily recognized by their reddish or brownish hues, which are the result of weathering and iron oxide accumulation over time.

Some come in the form of raised beach deposits, such as at Ċirkewwa and Ta' L-Imgħarrqa (Għadira Bay), and are composed of lithified calcareous sands with cross-laminations. These deposits mark ancient shorelines and provide evidence of past sea levels during periods of marine transgression and regression. Others, such at the coast of Għar Lapsi, are fluvial conglomerates and reflect ancient river systems that deposited coarse, terrigenous sediments during the Quaternary period. They not only tell a story of environmental shifts, from wetter climates to today's semi-arid conditions, but also hold clues about past sea levels, animal migrations, and climatic fluctuations that shaped Malta's geological and ecological heritage.

The cliffs at Dwejra (Gozo) close to where the Azure Window once stood.

On the edge of Mediterranean tectonics

The coastal landscape owes much to tectonic movements that faulted and tilted these formations. The islands' position on the Pelagian Block (a carbonate platform in the central Mediterranean Sea) has subjected them to tectonic forces that formed a series of faults which altered the structure of the islands and created a set of distinct structural regions. The ENE-WSW fault-oriented system, primarily represented by the Great Fault has influenced the northern part of Malta. It produced an alternation of horsts (uplifted blocks), and grabens (down-dropped blocks), which created headlands and bays (or rias) respectively along the coast.

To the north, parallel fault systems established a sequence of hills and low-lying basins, most visible as Wardija Ridge, Bajda Ridge, Mellieħa Ridge and Marfa Ridge and which are intersected respectively with bays ending from Binġemma Valley, Pwales Valley, Miżieb Valley and Mellieħa Valley. This faulted landscape allows visitors to experience a range of coastal features, from towering cliffs to secluded creeks and bays.

Additionally, intersecting faults from the NW-SE Pantelleria Rift, developed during the late Miocene and early Pliocene, are evident south of the Great Fault, notably the Magħlaq Fault. In trending parallel to the coastline, this NW-SE fault system significantly impacted the coastline of southwest Malta, particularly near Għar Lapsi and along the coastal cliffs of Dingli. It has created a prominent escarpment with a vertical displacement exceeding 200 metres and contributed to the steep cliffs of the region.

The faulting has led to the exposure of the Lower Coralline Limestone along the coast, forming vertical cliff faces that plunge directly into the sea. This has also resulted in a rugged, fractured landscape where erosion processes are intensified due to the structural weakness introduced by the fault line.

The fault systems have also contributed to a northeast tilt across the Maltese Islands, significantly influencing the landscape's geomorphology. This tilt elevated the western, southwestern, and southern coasts of Malta, exposing the Lower Coralline Limestone in steep or vertical cliffs that create dramatic seascapes. Meanwhile, the eastern and south-eastern coasts feature gently sloping shores. Gozo is also inclined to the NE. Its southern and western coast is characterized by cliffs reaching heights over 120 metres. Where valleys reach the coast, this tilt formed drowned valleys, or ria coastlines, marked by narrow creeks carved into the Globigerina Limestone and Lower Coralline Limestone. No wonder then that Malta's coastal towns and ports all lie on its eastern shores.

Rocks as blueprints: Nine coastal landforms

Thanks to its geology and geomorphology, the Maltese coast presents an impressive variety of landforms that represent the tension of forces at the edge between land and sea. In fact, among the Maltese Islands' most distinctive and picturesque landscapes, many are coastal in nature and can be categorized into nine types of coastal geomorphological landforms:

1. Rias or drowned valleys: During the late Pleistocene (around 20,000 years ago), sea levels were about 120 metres below today's levels. This period saw the formation of a river system extending four kilometres into the continental shelf. As sea levels rose with glacial melting, valleys along the shelf became submerged, resulting in ria coastlines, or drowned valleys, that now serve as natural harbours. Examples include the Grand and Marsamxett Harbours, Marsaskala, Marsaxlokk

Bay, and Wied Babu in Żurrieq. Gozo features similar landscapes at Mġarr ix-Xini, Xlendi, and Wied il-Għasri. In certain areas, these drowned valleys provided conditions conducive to saline marshlands, characterized by sheltered waters and abundant fine sediment deposits. These unique habitats, such as Għadira in Mellieħa Bay and il-Magħluq in Marsaskala, support distinct endemic ecosystems.

2. Low-rocky coasts: Gently sloping rocky shores, featuring pools and pinnacles, are prominent along the north-eastern shores of Malta and northern Gozo. Intense chemical and biological weathering of the LCL creates a rugged, irregular topography, as seen at Baħar iċ-Ċagħaq (Malta). Additionally, fractured LGL coasts offer ideal conditions for large boulders to become dislodged during storms, forming coastal boulder fields. Such boulder-strewn coasts can be found along Malta's north-eastern areas, including L-Aħrax tal-Mellieħa, Buġibba, Qawra, Pembroke, Xgħajra and Żonqor (Marsaskala).

3. Beaches (sandy, shingle, and boulder-strewn): Depositional beaches account for just 2.4% of Malta's coastline. Sandy beaches are more common than shingle beaches, making up 2.2% and 0.2% of the coast, respectively. These beaches are located mainly in sheltered bays bordered by rocky coastlines, where longshore marine currents deposit enough material to form sandy or shingle beaches. In northeast Malta, submerged graben features create shallow bays framed by promontories that align with the horsts. The alternating ridges and troughs in northern Malta expose BC to wave action, leading to fine sandy bays like Għadira Bay. Notably, in Gozo, only one beach, Ramla Bay, with its unique 'reddish' sand, interrupts the coastal scree slopes (MT: rdum) stretching from Marsalforn Bay's eastern headland to Daħlet Qorrot, marking a unique point where the BC and UGL layers meet near sea level. On some of these beaches, particularly in northern and northwestern Malta, Gozo, and Comino, remnants of aeolian landforms, such as sand dunes, can still be found. Notable beaches in Malta include Għadira (Mellieħa Bay), Ramla tat-Torri, Little Armier, Ramla ta' l-Armier, Ramla tal-Bir, Ramla tal-Mixquqa, and Ġnejna Bay. In Comino, sand dunes are present at Santa Marija Bay. In Gozo, ir-Ramla l-Ħamra hosts the largest sand dune system in the Maltese Islands.

4. Shore platforms: Along cliffs cut into the Globigerina Limestone, such as between Marsaxlokk Bay and St. Thomas Bay in Malta, shore platforms have formed due to differential erosion at lithological boundaries. At Miġnuna Point (Marsaskala), the LGL underlies harder layers of hardground and conglomerate, topped by the softer MGL. Wave action erodes the MGL marls more rapidly, causing the MGL to retreat and leaving a shore platform in the harder underlying layers. Other similar platforms can be seen at Xwejni Bay (Gozo) and Qammieħ Point (Malta). Shore platforms also develop in the UGL, where the erosion of a softer yellow marl layer exposes a more resistant yellow bed beneath. Notable examples include Delimara and Selmun in Malta and Għar Qawqla (near Marsalforn) in Gozo. Less common are shore platforms at the base of LCL cliffs, such as those at Maddalena and Buxieħ in Dingli, Għar Ħasan in Birżebbuġa, and between Xgħajra and Żonqor (Marsaskala). These LCL platforms form where a softer, gently dipping LCL bed is within the reach of storm waves, which erode the underlying layer, eventually causing the overlying LGL to collapse and creating a platform as the cliff face retreats. Where the soft LCL bed rises above the storm wave reach, platform formation ceases.

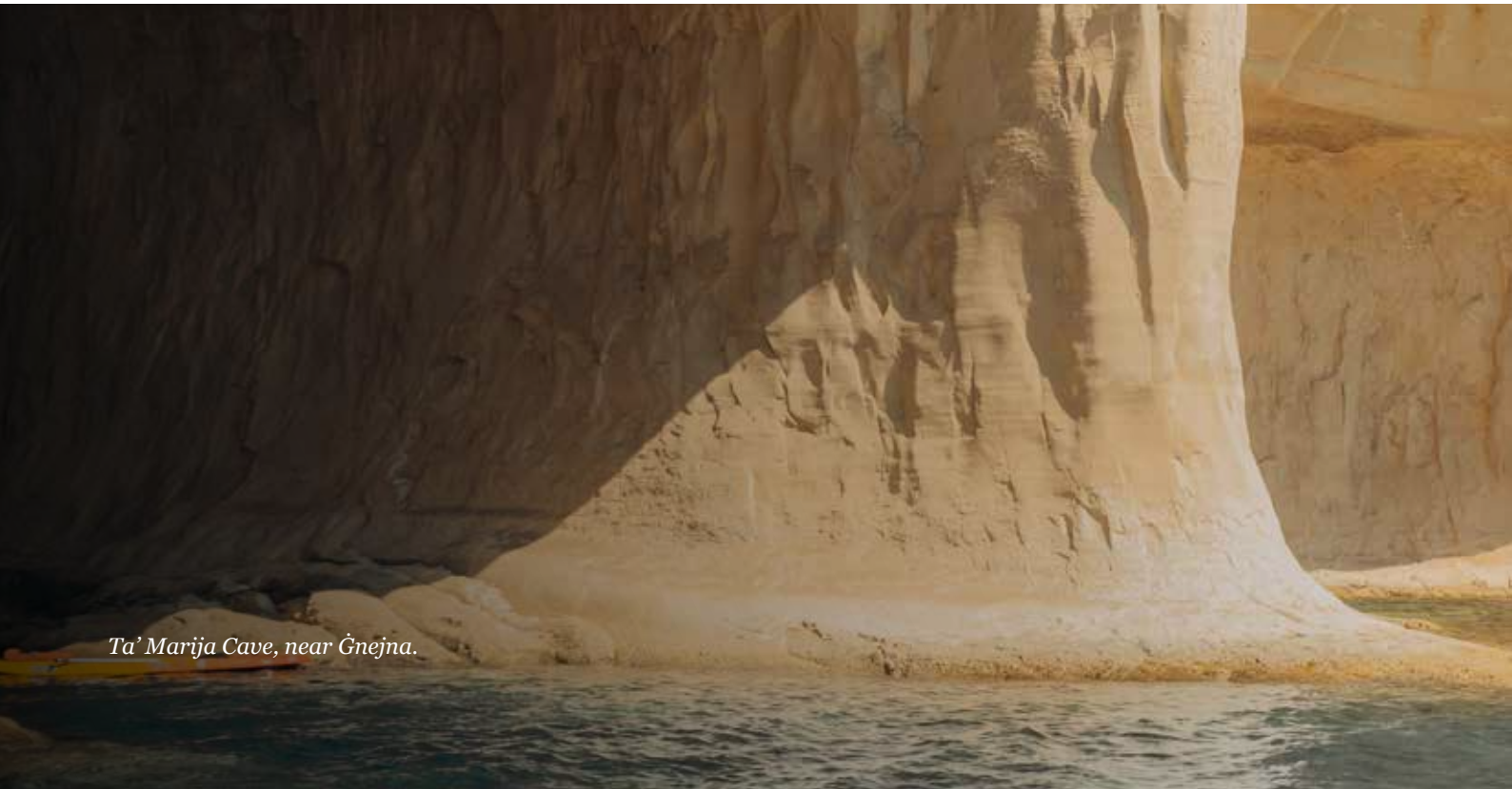
5. Scree slopes (MT: Rdum): Along the coastline from Fomm ir-Riħ to Ċirkewwa, a characteristic scree sloping morphology is observed, where large boulders of LCL detach from the upper plateaus, tumbling and sliding down across BC and UGL layers to reach the shore. Rainwater percolates through limestone fissures, reaching the clay below, which then becomes unstable. Faulting and

jointing in the UCL cause it to break up and descend onto the clay slopes. This process creates a shoreline bordered by boulder fields originating from the UCL uplands, with larger landslides occurring at the base of steep escarpments. This is visible at sites like Rdum id-Delli (Mellieħa), Ras il-Waħx (Manikata), and il-Karraba Headland in Għajn Tuffieħa (Malta).

6. Badlands: Coastal clay slopes in BC are characterized by steep gullies and deeply eroded valleys and best represented by the Karraba Headland in Għajn Tuffieħa, Selmun and Qammieħ Point along the western coast of Marfa Ridge. Some of these clay landscapes are colonised by steppe grasses, which slow down their erosion derived from gravitation-induced sediment transport.

7. Cliffs: Towering cliffs, ranging from 30 to 120 metres in height, comprise nearly half of the Maltese coastline. These dramatic cliffs define the landscapes of western and southwestern Malta, eastern Comino, and much of Gozo's coast. In Malta, vertical cliffs are primarily carved from the LCL, extending from Wied ix-Xaqqa (limits of Birżebbuġa) in the southeast to Fomm ir-Riħ (limits of Baħrija) in the west. At Għar Lapsi, the Magħlaq Fault reveals a fault plane, displacing the UCL by at least 230 metres downward to the south. This high-relief coastline is interrupted by lower-lying sections at Għar Lapsi and il-Magħlaq, where the fault has brought the UCL down to sea level. In Gozo, much of the coastline from Mġarr ix-Xini in the east, continuing clockwise to Ta' Ċenċ, Pinu Point, and Wied il-Għasri, consists predominantly of sheer vertical cliffs that expose the LCL.

8. Coves or sinkholes: Karst processes, influenced by the abundance of limestone across the Maltese archipelago, have led to the formation of unique coastal features, including semi-circular coves and sinkholes. These coves are classified into three main types: (1) solution subsidence structures that form by the collapse of karstic cavities and are now submerged by the sea, such as at Dwejra and Qawra (Gozo) and the Blue Grotto (Malta); (2) erosional circular coves, such as il-Ħofra l-Kbira and il-Ħofra ż-Żgħira (Delimara, Malta), which are created by differential erosion from waves acting on softer MGL marls under more resistant UGL layers; and (3) fault-bound circular coves, such as Ta' L-Imgħarrqa in Għadira Bay, where waves penetrate into fractures along UCL, eroding the softer GL to create circular coves.



Ta' Marija Cave, near Ġnejna.

9. Sea caves and arches: Sea caves are abundant along the coastline, typically forming where steeply dipping fractures or faults are present. Wave action gradually enlarges these weakened rock joints or fault planes into sizeable, circular caves or arches. When horizontal bedding is present, caves can extend up to 30 to 40 metres in width. In some cases, roof collapse has created a large blowhole, locally called a 'dragonara', at L-Aħrax on Marfa Ridge's eastern coast. Other famous sea caves include those near the Blue Grotto (Żurrieq) or Wied il-Mielaħ (Gozo). The caves on Comino have formed from a combination of limestone dissolution (karstification) along fractures and joints in UCL and marine erosion, which widened and tunnelled out these lines of weakness to form caves and tunnels, such as the Santa Marija Cave.

Other coastal caves located on elevated cliffs, such as Għar Ħasan, owe their formation to former wetter climate in the Quaternary period, which created elevated water table levels that saturated fractures, joints, and pores in the rock. In this saturated zone, water rich in dissolved carbon dioxide reacted chemically with the surrounding limestone or other soluble rocks, gradually dissolving it along lines of weakness, such as fractures and fissures. This process, known as chemical weathering, enlarges these pre-existing weaknesses and carves out cavities within the rock. As climate conditions shifted to a drier phase, water levels dropped, exposing these chemically weathered cavities to air. Over time, these areas of past saturation evolved into the caves we observe today, with their unique formations influenced by the original zones of chemical weathering along fractures and fissures.

Our coast's diverse landscapes are more than scenery; they are Malta's geoheritage, a shared and enduring memory of the Earth. Preserving these landscapes is not only about conserving their aesthetic value but also honouring the deep geological and geomorphological identity embedded in every cliff, beach and shore platform, which together enrich Malta's natural legacy.

Islets[16]

Godfrey Baldacchino

The islet of Filfla, with the Malta coastline as background.

Visitors to the Maltese Islands soon realise that 'Malta' is both the name of the country as well as the name of its largest, and most populated island. That is because Malta (the country) is actually The Maltese *Islands*, an archipelago. There are three populated islands: Malta, Gozo and Comino. But it doesn't stop there. There is an additional number of islands, islets and rocks, all currently uninhabited, but all part of the diversity of the country's 270 km coastline.

But: *how many islands, islets and rocks*? Lest one might think this is an exercise in banality, a limiting principle is applied so as to preclude us from considering rocks that are either very small and/or which barely abut the surface of the sea. Thus, we deliberately restrict our scope to consider islands, islets and rocks that: (1) have an official name; and (2) are at least 45 metres in length and/or breadth. This presents us with a set of 16 candidates, distributed as follows:

- eight – Manoel Island (the largest), St Paul's Island, Filfla and Filflett, Qawra Point, Għallis Rocks, Xrobb l-Għaġin Rock and Devil's End Rock – all around Malta;
- four - Fessej Rock, Fungus Rock, Taċ-Ċawl Rock and Ħalfa Rock – all around Gozo; and
- another four around Comino, of which three – Cominotto, Large Blue Lagoon Rock and Small Blue Lagoon Rock – lie around Blue Lagoon; while the fourth, Pigeon Rock, lies along Comino's south-western coastline.

There are various other named islets and rocks around the three main Maltese Islands. But these are generally smaller than the 16 featured here and therefore less conspicuous or salient. And: we *do* have to draw the line somewhere!

The significance of these natural features is considerable. Some are protected and 'no go' areas: they may require special permission to visit. That is because they are sites of ecological importance, and their fragile habitat is not meant to be disturbed other than by natural causes. Such features are meant to be viewed, and enjoyed, from a distance. Others can be visited and explored, sometimes on foot, sometimes with a boat, sometimes after a short swim. In any case, these 'satellite islets' represent less than 1% of the land area of the Maltese islands, but are, perhaps unexpectedly, rich in their ecological diversity. Indeed, their biodiversity is often quite different from that of the closest areas on the mainland. Let us review these 16 islands, islets and rocks in turn, starting with the Maltese octet.

Malta

Manoel Island - formerly 'L'isola del Vescovo'
(Bishop's Island)

By far the largest and the closet island to mainland Malta is Manoel Island. The island was called l'Isola del Vescovo [in Italian] or il-Gżira tal-Isqof in Maltese [Bishop's Island] since 1590, when it was acquired by the Bishop of Malta after a land exchange. Before that, it appears to have been known simply as l'Isola [The Island, in Italian], the only one in Marsamxett Harbour. Its current name dates from the 1720s and was assigned in honour of Grand Master Manoel de Vilhena who financed the impressive fortress that is this island's main architectural feature.

This is the easiest island to visit out of the 16, because it is located in an urban area [alongside the town of Gżira] and is connected to mainland Malta by a short bridge which can be used by pedestrians as well as motorists.

A temporary lazaretto was set up there during an outbreak of the plague in 1592; this was replaced by a more permanent structure some 50 years later, and now lies abandoned. There are also the remains of a Bovine Shed [MT: It-Tinda tal-Baqar], for the purpose of quarantining bulls and cows, and possibly the oldest building still standing on the island.

Currently a green lung in a densely populated area of Malta, Manoel Island is slated for a substantial urban development. Should this happen, it will become Malta's fourth inhabited island.

Still close to Malta, we find St Paul's Island(s) [Il-Gżira/Gżejjer ta' San Pawl]. This is the next largest island feature after Manoel Island. It is associated with the Christian Apostle Paul, and is located to the North of St Paul's Bay. The island is often referred to in the plural as 'St Paul's Islands', and with the Maltese names of Selmun and Selmunett (after the Salamone family), since a shallow and narrow isthmus divides it in two parts. The island boasts a coastal garigue environment, dominated by such flora as the hardy golden samphire and the Maltese fleabane, both with yellow flowers, as well as the red stonecrop. A statue commemorates the Apostle Paul and his visit to the Maltese islands in AD 60 – where he was allegedly shipwrecked in this very bay. The island bears traces of an abandoned building, a witness to earlier settlement. The island is also known in Maltese as Tal-Barba Marku: it was gifted to a certain Marco di Maria when, in 1576, while being chased by corsairs, he sailed through the 100-metre channel separating the island from Malta, which got the corsairs following in hot pursuit; but their boat ran aground, and this led to their capture.

On the edge of the other (south) side of St Paul's Bay, next to the locality of Qawra, we come across Qawra Point Rock, a low-lying islet that can usually be accessed on foot past a human-made oblong splash pool (MT: Il-Banju] and then over a 20m-long wet but shallow and unevenly rocky causeway: so, watch your step! Measuring some 200m by 120m, Qawra Point Rock [Il-Ġebla tal-Pont tal-Qawra] is also known as Ta' FraBen, the name of a long-standing catering establishment run by Frans and Benny at the Qawra Watchtower, close by – hence Fra+Ben – by which many locals know the area. On this sort-of peninsula, which acts as a breakwater to Salina Bay, appear three circles which, when viewed from the air, suggest a giant dart board, and aligned like the four cardinal points of a compass. At the very centre of this board is a blow hole (known in Maltese as Il-Ħanżira], and sea spray shoots out from here only when the gregale (N-E) wind blows. These 'three circles' are all that remains of a 20th century installation during the British period. It has been claimed that the islet was used for target practice, possibly by British navy vessels as well as the Royal Air Force. Plenty of spent cartridges have been found in the area, supporting such claims. The site also hosted A.M.E.S. No. 314, a World War II Ground Control Interception system, with a set of Yagi-antennas mounted on a 20m tower. Personnel on site would eavesdrop on air-to-air and air-to-ground radio telephony conversations between aircrew of enemy aircraft over Sicily (on their way to bomb Malta) and with their bases during WW II. These messages in the Italian and German languages would be swiftly translated into English and relayed to the War Rooms in Valletta as 'Intelligence'. Qawra Point, with the islet, is now a nature reserve. The Rock is also home to its own endemic species of lizard. In their 2010 study, the Sciberras brothers report that the salt-tolerant sub-shrub *Arthrocnemum macrostachyum* or glaucous glassword in English [MT: almeridja tal-blat] may be the only plant species occurring on the most exposed eastern and northern sides of this islet.

If one continues further south, hugging the North-East shore along the Coast Road, we soon glimpse the Għallis Rocks or shoal (MT: l-Iskoll tal-Għallis). The 250-metre stretch of sea between the Għallis Rocks and the coast is very shallow; but, at the edges, there are drop-offs to about 16 meters. The rocks

and their environs are a magnet for windsurfing enthusiasts. The feature qualifies as 'rocks awash': they are no higher than a metre above sea level; and so, they are better described as a shoal, and a serious navigational hazard, since they are completely washed over by surf when there is even a moderate swell in the sea. Great cormorants and gulls perch habitually on this shoal when the weather is calmer. There is no soil on the Għallis Rocks.

Much further down the eastern coast, past the Grand Harbour, and the settlements of Xgħajra and Marsaskala, one comes to a locality known as l-Iħfar [MT: The Holes] one of which is Il-Ħofra l-Kbira [literally, the Large Hole] along a peninsula known as Xrobb l-Għaġin (which translates literally as the syrup of dough). This is a site of immense natural beauty and now the site of a Nature Park, Hostel and Wildlife Regeneration Centre. Here lies the solitary Xrobb l-Għaġin Rock, 60m-by-30m in size, triangular in shape, known in Maltese also as It-Taqtiegħa [literally, the torn]. True to its name, this is yet another globigerina limestone coastal rock that got separated from the mainland, now about 40m away, many years ago. It is regularly inundated by wave action during rough weather. Again, no soil here.

The survey of islets along Malta's eastern shore ends with Devil's End Rock [in MT: Il-Ġebla tax-Xifer l-Infern, which translates literally as the Rock at the Edge of Hell]. This lies just beyond the tip of the Delimara Peninsula, in Malta's extreme south-east. This is another weathered globigerina limestone rock, some 40m-by-45m in size, flattened and regularly battered by the sea from all sides. Like various other named islets around Malta, it is too small and exposed to host any soil or any terrestrial vegetation. This piece of squarish, coastal rock would have been part of the shoreline of the peninsula, eroded and cut off by the ravages of time due to extreme weather and sea erosion, and now located some 40m from the mainland. It is a peril for seafarers; and is situated directly below the Delimara lighthouse. The seabed around the islet is littered with some large boulders, among which divers can glimpse groupers; while stingrays lurk beyond the boulders, on the open, sandy seabed.

Finally, and turning towards the west of Malta now, we find the duo Filfla and Little Filfla, known in Maltese as Filfla and Filflett (the latter also known as il-Ġebla ta' Xutu [Xutu's Rock]). This pair of islets is the furthest from the Maltese mainland – 5.2 km away – and can only be visited after securing a special permit. Their name is probably derived from felfel, an Arabic word for pepper. Since Filfla was extensively used for target practice by various naval vessels in the past, its scarred rock face remains unstable, and there may be unexploded ordnance in the vicinity: which adds a safety concern to discourage any visitors. Filfla and Filflett are best enjoyed from Malta's south-west shore, such as from the vicinity of Ħagar Qim or Mnajdra Temples – with which it may have had a connection – or from the hamlet of Wied iż-Żurrieq, where there is the Xutu Tower (see the 'Coastal Towers' chapter below). A wall lizard and door snail are endemic to the isles, which are also home to a colony of European Storm Petrels.

Gozo

Fungus Rock, a prominent feature along Gozo's western coastline.

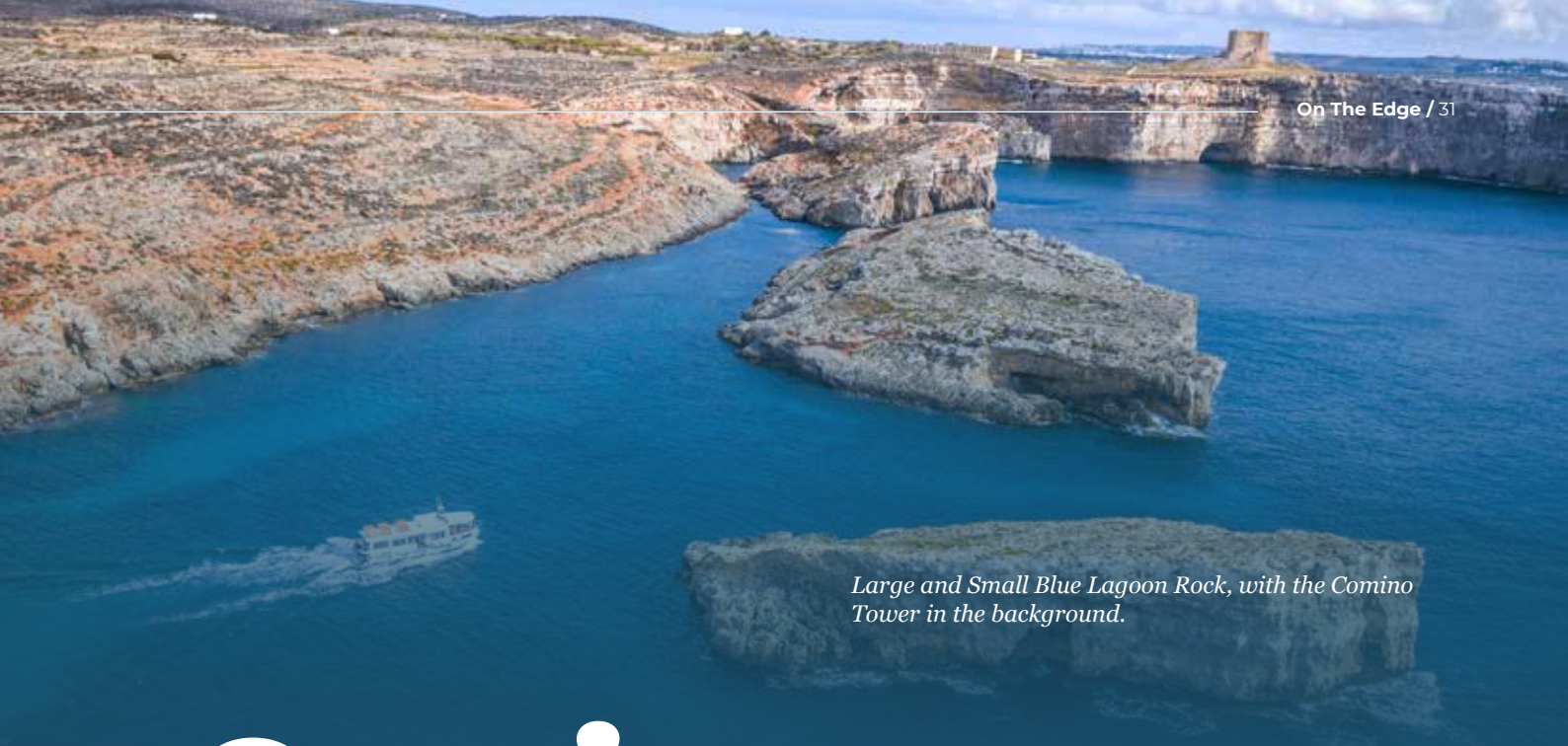
We move next to Gozo, the second largest island in the Maltese archipelago. All its islet or rock formations are small. In any case, they still nurture hardy species of flora and some fauna, able to survive in an often-arid environment, with sparse soils, sea spray, and strong winds prevailing from most directions. Three of our four candidates on the island of Gozo hug its indented southern coast.

Furthest to south-west, near the entrance to the narrow inlet of Mġarr ix-Xini, is *Fessej Rock* (also known as Black Rock) [MT: Il-Ġebla tal-Fessej]. The rock is actually a pillar, rising some 15 metres out of the water, with the sea plunging down alongside the almost vertical wall of this pinnacle to a depth of some 50m. It is the home of a bewildering diversity of marine life beneath its surface: no wonder then that it is a mecca for divers and snorkellers. Some predatory fish have been seen lurking in the area, such as dentex, barracuda and tuna; but also, lots of other common fish such as groupers, as well as tube worms, seahorses and the occasional octopus hidden in the many cracks and fissures. Described on *My Diving Map* as "a majestic geological formation," the islet was declared a Special Area of Conservation of National Importance in 2024.

Moving east, about 1km past the busy harbour of Mġarr, we reach *Taċ-Ċawl Rock*. (In Maltese, MT: Il-Ġebla taċ-*Ċawl, where ċawl* can refer to either the locally extinct jackdaw bird, or the damselfish.) This is a semi-islet, 90m x 35m in size, rising up to 6m above sea level, located about 25m away from the mainland cliffs, with the gap taken up by a mass of limestone rock debris, washed clay and other boulders, indicative of a rock fall that probably created the islet in the first place. Taċ-Ċawl Rock is replete with caverns, tunnels and arches. The rock remains isolated from the mainland, because the opposite mainland cliffs, while reachable on foot over rough terrain, are sheer cut and the islet is thus not accessible except via the sea and the rock's low-lying south-east shore. Fifty-six plant species, of which four are endemic, were recorded by Stephen Mifsud during two surveys – one in spring, one in autumn – in 2011. A few specimens of the protected and endemic *Podarcis filfolensis* (Maltese Wall Lizard) were also observed there.

Tal-Ħalfa Rock is about 95m x 50m in size and located some 75m away from the Gozo mainland, east of the bay of Ħondoq ir-Rummien. The rock sits off a secluded shingle beach, with large pebbles and golden sand. A chain of submerged rocks, collectively known as the Ħalfa is the name for Stipa tenacissima, or esparto grass in English: a hardy plant native to North Africa. But, more dramatically, the word stones [MT: Ġebel tal-Ħalfa], lie within 400 metres of this islet. 'Ħalfa' means 'oath' in Maltese: One legend has it that Turkish pirate and admiral Dragut swore to avenge his brother's death in Gozo in 1544 on this rock; in 1551, he carried practically the whole Gozitan population into slavery possibly as an act of revenge. Ħalfa Rock is on the Maltese Islands' Natural Heritage List, has the status of an area of ecological importance and is a special area of conservation. There is a roundish, vertically dug cavity some 2.5m in diameter and 4m deep on this rock's south-eastern side. The National Heritage Trust Din l-Art Ħelwa describes it as the location of a fougasse (a rock-hewn mortar designed to fire large quantities of stone) installed there in 1743 to defend against pirate attacks. But the object may well be a sinkhole. Whatever its origins, the place is a rock pool frequented by some swimmers in summer. Fifty-nine plant species were recorded on this rock by Stephen Mifsud during his two surveys in 2011, of which two are endemic. The Maltese Wall Lizard also makes an appearance on this rock.

This leaves us with the jewel on Gozo's west coastline, at the mouth of Dwejra Bay, and the tallest islet of the Maltese islands: *Fungus Rock* [MT: Ġebla tal-Ġeneral, or General's Rock]. A prominent, 60-metre-high limestone pillar, it was designated as part of a Special Area of Conservation in 1992. Since March 2017, the Fungus Rock is *the* landmark of a nature reserve, after the Azure Window collapsed into the sea. It is located at the entrance to a circular lagoon in Dwejra: one of four sinkholes in the area. Its English name comes from a plant, *Cynomorium coccineum*, popularly known as 'the Maltese fungus', but actually a flowering plant, with a somewhat phallic appearance, and which grows on the rock's flat top. The plant – known locally as *Għerq is-Sinjur* [literally translated as The Rich Man's root] – was claimed to possess medicinal properties in the 18th century; but this claim is disputed. Still, the Knights of St John used it as dressing for wounds and a cure for dysentery. They so prized the plant that they guarded it jealously and only offered it as a gift to distinguished visitors. Because of this plant, Fungus Rock has been protected for some 280 years: Grand Master Manuel Pinto decreed the Rock out of bounds in 1746. Anyone caught trespassing faced a three-year spell as oarsman in the Knights' galleys. A permanent guard was posted and a cable-car basket from the rock to the mainland, 50 metres away, was put in place as the only authorised means of access. Pinto also ordered the rock's sides to be smoothed in order to remove handholds. And so, the Fungus Rock is very difficult to climb up or down from. On suitable days, the sunset can be photographed through an opening in Fungus Rock from the inlet anchorage. While the fungus on the rock is not endemic, a particular subspecies of Maltese lizard is: *Podarcis filfolensis ssp. generalensis,* with its reddish belly and blue-like flanks. Fungus Rock is best viewed from Dwejra Bay, as well as from the top of Dwejra Tower (check opening days and times).



Large and Small Blue Lagoon Rock, with the Comino Tower in the background.

Comino

Finally, we head to Comino, where a set of three islets huddle around the idyllic Blue Lagoon. Comino's negligible population (currently: 2) and limited economic activity mean that its natural environment still offsets the human presence most of the year. But, come the summer months, frequent ferries and private boats from both Malta and Gozo bring over many day-trippers, resulting in a heavy presence in Blue Lagoon, which has become a popular summer beach site. Cominotto, Large Blue Lagoon Rock and Small Blue Lagoon Rock [Kemmunett u l-Ħaġar ta' bejn il-Kmiemen] are therefore some of the most looked-at islets in Malta. The rocks themselves bear the scars of millenary erosion, with the Large Blue Lagoon Rock sporting a 'window' right through its limestone. Only the hardiest species can survive in such extreme and unforgiving settings, permanently swept by the often-strong winds and sea spray of the Gozo Channel and nurtured by the shallowest of soils. At 0.25 km^2, Cominotto is the largest of the trio: it bears traces of agricultural practices in times gone by. The complete set of islets and inland waters around Comino, and including Comino proper, are designated as a special protection area.

We conclude this survey by acknowledging an islet off the cliffs on the south-west coast of Comino, 330m to the south-east of the Blue Lagoon Rocks. Called Pigeon Rock or Cliff Face Rock in English, its Maltese name is Il-Ġebla ta' taħt il-Mazz, or Tal-Mazz Rock, since it is situated near the Tal-Mazz cliffs. This rock supports various shrubs and plants, and it is a haven for wildlife, including many feral pigeons, which breed there; hence its English name. This islet, 20m by 45m, stands a maximum of 20 metres out of the water: it has vertical sheer cliffs on its east (Comino facing) side; while its western side, while still sheer, is slightly less steep. It is situated around 20m away from the Comino mainland, and contains some terrestrial vegetation, rooted in accumulated natural debris. It is accessible with a shallow keelboat. Inula crithmoides (golden samphire) is the dominant flora on its eastern face; while the salt-resistant Darniella melitensis (Maltese salt tree), a dense perennial shrub which is the largest endemic shrub in the Maltese Islands, dominates on its west. The endemic flowering plant Matthiola incana melitensis, known as the Maltese stock [MT: Il-Ġiżi ta' Malta], which is strictly protected, can also be found there. In rough weather, the lower area of the islet is inundated by wave action; but the topmost areas are generally spared from this.

Caves and Arches[6]

Keith Buhagiar

'The Window' at Wied il-Mielaħ, limits of Għarb, along Gozo's rugged north coast.

The Maltese Islands boast a rugged coastline marked by steep cliffs, hidden coves, and an array of natural geological formations. Among these, the coastal caves and sea arches stand out, offering a glimpse into the power of nature eroding the coastal geology and adding to the timeless beauty of the archipelago's landscapes. These formations are not just geological wonders; they are also cultural landmarks, with many tied to local legends, historical events, and modern popular culture.

Exploring Six Famous Coastal Cave Complexes and Arches

This essay explores six of the most famous coastal cave complexes and arches of the archipelago: The Inland Sea and the (now defunct) Azure Window, both in Dwejra, Gozo; 'The Window' at the end of Wied il-Mielaħ (MT: It-Tieqa ta' Wied il-Mielaħ), limits of Għarb, Gozo; the Blue Grotto at Żurrieq and In-Niffied at Qrendi, both in Malta; and a series of caves on the island of Comino which featured prominently in the 2002 movie The Count of Monte Cristo, directed by Kevin Reynolds. Some of the arches featured here are visible from land. Others, however, including most of the sea caves, are only accessible by sea and are best reached either by kayak or other small seacraft.

Entrance to Blue Grotto, limits of Qrendi, SW Malta, with Filfla in the background.

Blue Grotto (Qrendi, Malta)

A fascinating stretch of coastline on the main island of Malta, stretches from the Blue Grotto area in Qrendi, right until Għar Lapsi in Siġġiewi. This stretch of Malta's southwestern coast is a geological paradise, an area known for its dramatic cliffs and rugged beauty which extends in a north-westerly direction to Dingli and beyond. Visible in the distance is the uninhabited isle of Filfla which, when combined with the charming Blue of the Mediterranean Sea and the dramatic nature of the coastline, adds to the spellbinding charm of this area.

The Blue Grotto area is synonymous with numerous sea caves and a majestic sea arch, locally known as 'The Arch' [MT: Il-Ħnejja]. The geology is like that of Dwejra and primarily consists of exposed Globigerina and Lower Coralline Limestone deposits. Most of the sea caves and Il-Ħnejja are the result of Lower Coralline Limestone erosion through the process of hydraulic action and attrition, amongst other erosional aspects. Hydraulic action is the sheer force of water crashing against the coastline, causing material to be dislodged and carried away by the sea. Attrition is when material such as rocks and stones carried by waves hit and knock against each other wearing them down.

The sea at the Blue Grotto is renowned for its stunning and vibrant colours. The water exhibits a striking array of blues, ranging from deep sapphire to vivid turquoise, depending on the depth and the angle of the sunlight. The intense blue hues are especially prominent on sunny days when the light penetrates the clear waters, illuminating the white sandy seabed and reflecting off the limestone walls of the grotto. Il-Ħnejja can be either viewed from land from a well-signposted viewpoint before descending to Wied iż-Żurrieq, or via boats which regularly depart from the creek at Wied iż-Żurrieq. The caves and Il-Ħnejja can be explored by kayak during calm seas and will also provide an excellent snorkelling experience.

In-Niffied (Qrendi, Malta)

The In-Niffied area is a lesser-known landmark, a visit to which can be combined with the exploration of Ħaġar Qim and Mnajdra prehistoric temples, classified as UNESCO World Heritage Sites. The In-Niffied coastal area lies beneath the 17th -century coastal watchtower, whose name can be translated freely as 'The soil tower' [MT: It-Torri tal-Ħamrija]. A series of footpaths close to the entrance gate of Mnajdra temples descend towards the coast, but reaching In-Niffied requires good walking gear and trekking equipment and is not to be attempted by the fainthearted. Once reaching the coast, visitors are rewarded with a spectacular geological landscape, shaped over the millennia, not only by coastal erosional processes, but also by significant tectonic movement which scarred the western coast of Malta through the creation of numerous fault lines (the Magħlaq Fault). [In fact, the noun niffied is best translated as 'an area that is punctured, or stabbed', indicative of the landscape's dramatic character.] At In-Niffied, land faulting was so significant, that Upper Coralline Limestone deposits, Malta's youngest and uppermost rock deposit, are found at sea level. However, the adjoining ridge on which the historic Torri tal-Ħamrija is placed, is composed of Lower Coralline Limestone.

In-Niffied is characterised by a wide array of micro-toponyms or placenames, the better known of which are: Il-Mitqub (freely translated as 'an area with holes'), 'The Tongues' [MT: L-Ilsna] and the Soil Promontory [MT: Ras il-Ħamrija]. Il-Mitqub is a narrow creek, the smooth, near-vertical face of which is part of the Magħlaq Fault system. L-Ilsna is an Upper Coralline Limestone promontory at the tip of which are a series of scattered rocks or stumps. These are in essence the remains of eroded sea arches. When a sea arch collapses, the column (stack) commonly survives. An eroded stack is in geological terms identified as a stump. The eastern portion of In-Niffied is characterised by a series of small coastal caves including a couple of small sea arch formations, a glimpse of which can be easily obtained from the coast. Visitors to In-Niffied can enjoy the beauty of the area in relative solitude. It remains off the beaten path for most tourists.

The Inland Sea (Dwejra, Gozo)

Dwejra, to the north-west of the island of Gozo, is accessed through the quaint village of San Lawrenz. The Inland Sea is colloquially known as Il-Qawra, [which can be translated as a 'creek', and not to be mistaken with its namesake in St Paul's Bay, Malta]. It is one of the Maltese Islands' most intriguing natural wonders and a major tourist attraction. This shallow, saltwater lagoon is connected to the Mediterranean Sea by a narrow natural tunnel that runs through a massive limestone cliff, creating a unique and picturesque landscape. The formation of this geological feature makes for a fascinating story of geological dynamism.

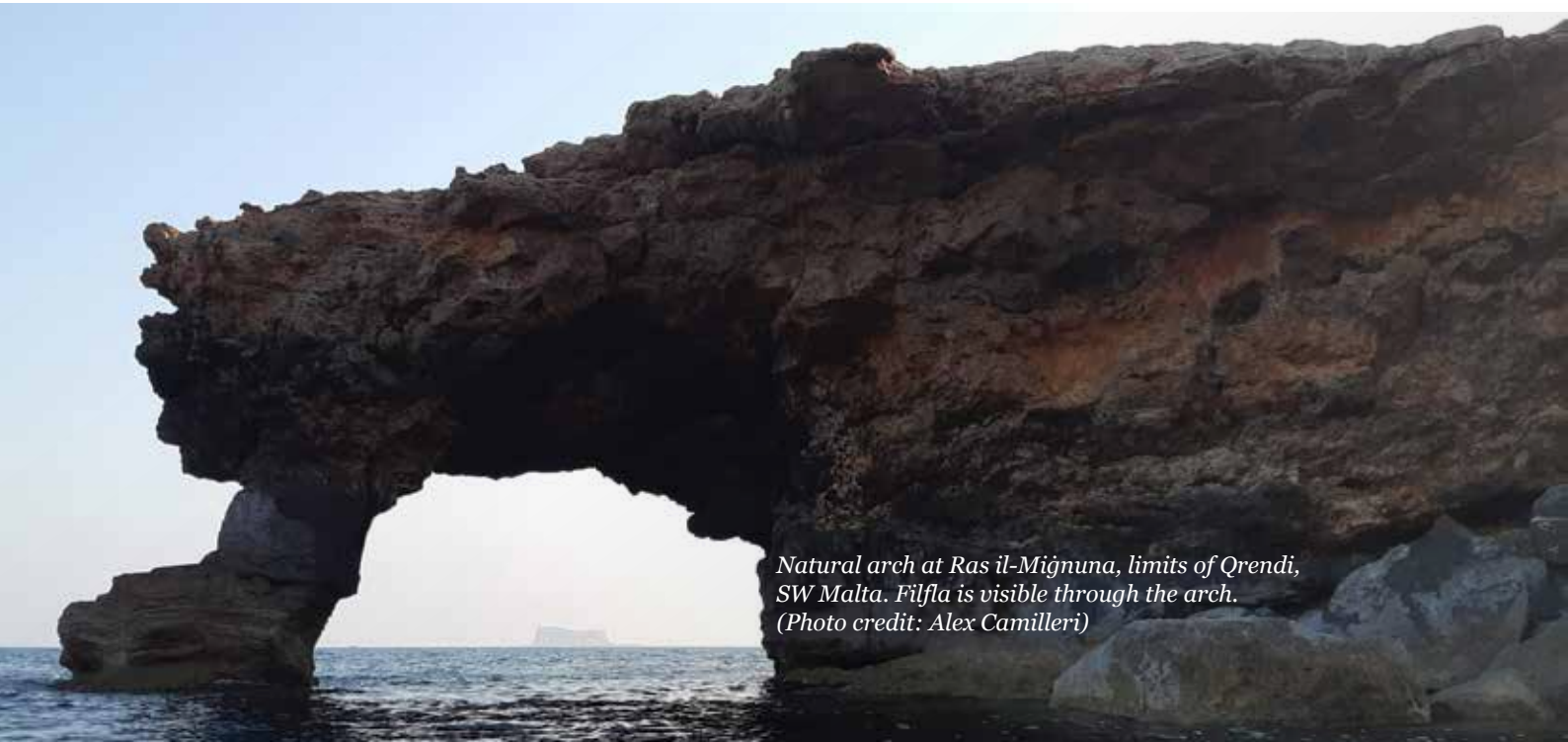
The Maltese Islands are primarily composed of sedimentary limestone deposits which, when undisturbed by land faulting, consist, starting from top to bottom of: Upper Coralline Limestone; Blue Clay; Globigerina Limestone; and Lower Coralline Limestone. The Inland Sea is primarily surrounded by Globigerina and Lower Coralline Limestone formations, rocks that were formed in an underwater environment, from the accumulation of coral and marine organisms, millions of years ago during the Oligocene and Miocene epochs. Over time, this limestone was uplifted above water and exposed to the forces of erosion.

The formation of the Inland Sea resulted from a combination of land faulting and limestone dissolution. Land faulting happens when there is a crack or break in the Earth's crust, causing the land on either side of the crack to move. Limestone dissolution is a result of chemical weathering leading to the gradual dissolution of limestone by slightly acidic rainwater, forming a series of underground caves. This process happened over a period of thousands of years. Eventually cave-ins created a depression that filled with seawater, forming the lagoon we see today. Landscapes in which limestone dissolution typically occurs are identified as karst; and geological formations, as in the case of Dwejra's Inland Sea, are known as sinkholes or dolines.

The most striking feature here is the narrow tunnel – locally known as the Qawra Cave [MT: L-Għar tal-Qawra] or Dwejra Cave [MT: L-Għar tad-Dwejra] - that connects the Inland Sea to the open Mediterranean. (Dwejra, by the way, is a 'small house' in Maltese). This tunnel, about 80 meters long, was similarly formed through the process of erosion. Waves relentlessly pounding against the limestone cliffs, gradually enlarged a natural fissure or a point of weakness in the cliff-face, until it became a tunnel, allowing seawater to flow into the Inland Sea, creating the resultant lagoon. L-Għar tal-Qawra is wide enough for small boats to pass through. However, note that this tunnel was, at some point, somewhat enlarged by human intervention.

The Inland Sea is relatively shallow, with depths ranging from a few meters near the shore to about 15 meters at its deepest point near the tunnel entrance. The calm waters of the lagoon contrast sharply with the often-rough seas just beyond the tunnel, making it a popular spot for swimming, snorkelling, and diving. The surrounding cliffs provide shelter from the wind, further enhancing the tranquillity of the site.

Today, the Inland Sea is a popular tourist destination, attracting visitors with its natural beauty and unique formation. It offers a glimpse into the dynamic geological history of Gozo and serves as a reminder of the powerful forces of nature that continue to shape the archipelago. Whether viewed from the shore or explored by boat, the Inland Sea remains one of the most captivating natural geological features of the Maltese Islands.



Natural arch at Ras il-Miġnuna, limits of Qrendi, SW Malta. Filfla is visible through the arch. (Photo credit: Alex Camilleri)

The (former) Azure Window (Dwejra, Gozo)

Close to the Inland Sea was the Azure Window, a sea arch known locally as 'The Window' [MT: It-Tieqa] or The Dwejra Window [MT: It-Tieqa tad-Dwejra]. This was one of Malta's most iconic natural landmarks until its spectacular collapse during a heavy storm on 8th March 2017. (Malta's then Prime Minister described the loss as 'heartbreaking'.) The Azure Window featured in a series of well-known cinematographic productions, amongst which are 2002 The Count of Monte Cristo movie and episodes from the first season of the Game of Thrones series.

It-Tieqa tad-Dwejra was formed by the erosion of a Lower Coralline Limestone headland known locally as L-Ixprun. The first recorded instance for the sea arch is an 1824 illustration, where it serves as a backdrop to the nearby Dwejra Tower. Lower Coralline is amongst the hardest rock deposits found in the Maltese archipelago. However, the combination of wind, rain, and the constant battering of waves still succeed in gradually weakened the rock. A typical erosion process involving the formation of an arch involves the weakening of rock fissures in a headland to form a notch. This is gradually enlarged into a cave and finally an arch. Standing at around 28 meters high, the Azure Window was a striking feature of monumental proportions, especially when viewed against the backdrop of the deep blue Mediterranean Sea. Right until its destruction, it was arguably one of the better-known sea arch formations worldwide. What came as a surprise to many, however, was that it was not only the arch ceiling which collapsed. The massive waves which on that day mercilessly pounded the Dwejra coastline, also swept away the huge pillar, leaving behind a nostalgic and emotional void where the majestic arch once stood.

Today, the site remains a point of interest, with divers exploring the underwater remnants of the collapsed arch. The nearby 'Blue Hole' [MT: Iż-Żirka], a 10-metre wide and 15-metre-deep circular depression, connected to the adjoining sea by means of an underwater arch, is another popular diving spot. The Iż-Żirka placename is probably a reference to the vibrant shades of blue exhibited by the sea in this area. Divers continue to explore the area where the Azure Window once stood. Huge boulders of limestone rock, still cracked and sharp-edged, are strewn across the seabed. The collapse of the Azure Window sea arch is one of the best things to have happened to Gozo, some divers have claimed.

‘The Window’ at the end of Wied il-Mielaħ / It-Tieqa ta’ Wied il-Mielaħ (Għarb, Gozo)

The Azure Window was Gozo’s best-known sea arch, but it was not the only one. There is another ‘window’, [tieqa, in Maltese], this time located at the end of a valley known as Wied il-Mielaħ [The Maltese word mielaħ is the adjective derived from melħ, which means salt] [hence MT: It-Tieqa ta’ Wied il-Mielaħ] still stands and has gained much more attention since 2017 as a ‘replacement’ for the Azure Window, although it remains a lesser-known gem. Located in the secluded northwest part of Gozo, Wied il-Mielaħ window is best reached from the village of Għarb. The window is located at the point where the river-carved valley of Wied il-Mielaħ meets the sea. The geology of the area is like that of Dwejra: It-Tieqa ta’ Wied il-Mielaħ was formed out of a Lower Coralline Limestone outcrop. Even though smaller than the Azure Window, its setting in a narrow valley gives it its unique charm. The surrounding area is characterized by steep cliffs, rocky outcrops, and a wild, untamed landscape that is perfect for hiking and nature walks. A visit to Wied il-Mielaħ offers visitors a chance to experience the natural beauty of Malta’s coastline in a more tranquil and less commercialized setting. It remains in relatively good condition. But like all similar formations, nature giveth and nature taketh away: it will eventually suffer the same fate as the Azure Window.

Comino and the ‘Count of Monte Cristo’ caves

Comino, the smallest of the three main Maltese Islands, is a place of rugged beauty, and during the winter months, isolation. The island currently only has two permanent residents. It is best known for its crystal-clear waters, the remnants of a submerged river-carved valley known as Ta’ Bejn il-Kmiemen or the Blue Lagoon, Santa Marija Bay, and the lesser-known San Niklaw Bay. However, there are a wide array of caves and coastal features scattered all around the island’s circumference. Located roughly mid-way between Malta and Gozo, Comino has a similar geological make-up to the rest of the archipelago. However, due to land faulting which caused substantial land subsidence, only Upper Coralline Limestone is present above sea level.

The Blue Lagoon is an outstanding example of such a formation. [By the way, the original Maltese name of this area is much more prosaic: Bejn il-Kmiemen, which translates as ‘between the Cominos’] Both sides of the lagoon, including the islet of Kemmunett and the neighbouring stacks, all formed part of this valley system, the sides of which were destroyed by the process of marine erosion. Caves abound in this area, with one of the most idyllic being ‘The Cave under the Tower’ [MT: L-Għar ta’ Taħt it-Torri], located right beneath the early 17th -century St Mary’s Tower. This cave extends into the cliff-face for over 30 metres and leads to a small, secluded underground sandy beach. This cave features prominently in the 2002 Count of Monte Cristo movie, in which it fictitiously gave access to the overlying tower masked as the infamous Château d’If, the prison where the protagonist Edmond Dantès was held captive. Another highlight is the Roofless Cave [MT: L-Għar ta’ Bla Saqaf], another doline structure, where the ceiling of a sizeable coastal cave collapsed, adding charm to the geological beauty of the area. Most of these are accessible only by sea, and visitors can explore the caverns by boat or swim through the crystal-clear waters that fill them.

Similarly, marine caves abound in the Santa Marija Bay area. With help from anyone familiar with the topography of this area, a cave system known as The Imnieri Caves [MT: L-Għerien ta' l-Imnieri], can also be reached by land. These caves were likewise utilised in the 2002 Monte Cristo movie as the spot in which Edmond Dantès located the treasure trove. Other coastal landmarks worthwhile a visit include Id-Darsa [which can translate as 'the molar' or else as something challenging], a coastal arch which in the 2002 Monte Cristo movie features as "elephant rock", and another smaller arch, found in the south-eastern corner of Comino, known as' The Arch' [MT: Il-Ħnejja].

The coastal caves and arches of the Maltese Islands are not just natural wonders; they are also a testament to the archipelago's rich geological history and cultural heritage. The caves described in this feature primarily occur in either Upper Coralline Limestone deposits, as in the case of Comino and In-Niffied, or Lower Coralline Limestone, as in the case of Dwejra, It-Tieqa ta' Wied il-Mielaħ and the Blue Grotto. Over time, the waves, wind, and rain have carved out these spectacular formations, creating natural landmarks that are both beautiful and fragile. The caves are home to a variety of marine life, including fish, sea urchins, and starfish, making them popular stops for hikers and explorers, and attractive spots for snorkelling and diving. These can be some memorable destinations for those visiting the Maltese Islands.

Comino Caves that featured in The Count of Monte Cristo movie (Photo credit: Kaylee Burger).

Ports[6]

Thérèse Bajada

Fort St Angelo, commanding the entrance to Grand Harbour, with the Saluting Battery in Valletta in the foreground.

“When I was in the Navy...”

Whenever I heard my grandfather start a sentence in this way, I knew that he would be recollecting some wartime adventure. He was a Chief Petty Officer with the Royal Navy during World War II. The ships on which he was assigned called in several ports around the world. This is one reason why ports fascinate me, and this is where I developed my interest in geography. He used to talk about visiting the port of Alexandria, Egypt, and how he experienced the hustle and bustle of the *souks*. As a child, I would daydream about the vibrant colours, the fragrant smells and the lively atmosphere that there would be. He talked about passing through the narrow Strait of Gibraltar while travelling to Portsmouth, crossing the Atlantic to reach the Caribbean Islands and recounting the time when he navigated through the Bermuda Triangle. I was curious albeit relieved as to why his ship did not go missing there. Such and similar experiences were possible because of Malta’s geo-strategic location, which led the archipelago to serve as a hub for the British Navy for one and a half centuries.

The nature of ports

Ports play a crucial economic and social role. The word port comes from the Latin word *portus*, which means “haven” or “harbour”. They are sites that provide refuge in storms and serve as safe spaces where people of different values, languages and customs meet, in the name of free exchange and trade. Ports are maelstroms of human activity, nowadays involving tourists, chandlers, sailors, insurers, marine engineers, dockside employees and hospitality services.

Ports have a role in the three pillars of sustainability: economy, environment and society. The challenge is striking the right balance between these three pillars: ensuring a healthy economy, a pleasurable and clean environment, and decent quality of life for the people involved, whether residing, working or visiting.

Ports are dynamic and complex. They are affected by spatio-temporal situations, which the sites experience based on their geo-location. To understand ports and their intricacies, one requires zooming in onto the local situation and then zooming out to the national and international context. Ultimately, it is this complexity that places ports at the heart of the connectivity that drives our maritime world.

Malta's geography as destiny

Malta's geographic location is at the heart of the Mediterranean Sea, which throughout the years dictated that the archipelago played major geopolitical and strategic roles. Malta's rich and turbulent history, in fact, is indelibly linked with its geographic location. Regional powers coveted Malta for its natural harbours. Corsairs raided the islands with impunity, stealing crops and livestock and killing or enslaving unfortunate members of the local population. The archipelago was heavily bombed by enemy aircraft during World War II, and notably during a raid on the UK aircraft carrier *Illustrious* while berthed in the Grand Harbour for repairs, in mid-January 1941.

In spite of all this, location has also been fortuitous: it has shaped Malta's economy and helped to nurture the resilience of its people. A fervent disciple on his way to Rome from Judaea was shipwrecked here and endowed the country with its Catholic faith. Two current examples include the rich and abundant history, which is a national pride and which feeds into the tourism industry, and the contribution that Malta has made to maritime logistics, and which involve seafaring and the sea lanes that cross the Mediterranean Sea.

Geographical proximity is a geographic term that highlights the importance of Malta's location. Beyond the concept of absolute location, which is provided by fixed coordinates, proximity is a relative term, characterised by space, distance and temporality. The ports of Malta through the years were influenced by the islands' proximity to three continents, forging strong maritime and population links between the coastal regions of the Maghreb, in North Africa, the central parts of Southern Europe, and the Middle East.

Malta's history is deeply entangled into the unique features of the Grand Harbour, a coveted deep water, all-weather, naturally sheltered feature and quite unique in the central Mediterranean. For centuries, the Grand Harbour and its creeks served as the secure location for the galleys of the Knights of St John and then for the British Mediterranean Fleet. Intense ship repair and (for some time) shipbuilding activity engaged the bulk of the adult male population of the Islands. Dock Number 1 – one out of seven docks in French and Dockyard Creeks – has been refurbished as a recreational area; the other six remain in operation.

Grand Harbour is now a densely multifunctional arena, serving multiple commercial, residential, recreational and industrial facilities. Three additional areas offer port services in the Maltese Islands. These are Ċirkewwa (Malta) and Mġarr (Gozo), the respective end and berthing points of the ferry service across the 8km Gozo Channel, and, in the case of Mġarr, much more besides; while Marsaxlokk Bay has taken on the overflow from Valletta and is now dominated by the Malta Freeport Terminal on one side and the Delimara Power Station on the other, with the communities of Marsaxlokk and Birżebbuġa nudged in between. Two additional coastal areas – Xlendi in Gozo and Burmarrad in Malta – served as ports in ancient times.

Valletta's twin ports: Grand Harbour and Marsamxett Harbour.

Xlendi and Burmarrad

While the geographic location placed Malta at the nexus of cultural diversity, its geomorphology shaped the natural harbours that characterise the archipelago. The inlets and bays made Malta a perfect location for seafarers, well-meaning and otherwise, to find shelter. For example, during Punic times, Xlendi in south-western Gozo served as a port. The bay there is sheltered, but when ships went out in the open sea and encountered rough seas, unfortunate events led to the sinking of vessels. Archaeological remains that still lie on the seabed in the area provide evidence of such mishaps.

Another important port was that of Burmarrad, which lies in the north-east of mainland Malta. During Punic, and later Roman times, the area was bustling with activity. The Romans constructed a series of saltpans (salini) in the rock there, as the salt industry flourished at the time. Salt was considered as the gold of that period, because it was important for the preservation of food. Such locations were the hubs of everyday life that attracted people to live, settle in the areas and establish their burial sites close by. Both Xlendi and Burmarrad are nowadays areas of archaeological importance, which attract tourists for their history and for exciting scuba diving activities.

Grand Harbour

With the opening of the Suez Canal in 1869, Malta's ports attracted and serviced seafarers from across the world: during the British period, ships docked in Malta as a port of call on their way from Britain to India, and back. This led to the flourishing of the local economy with an injection of foreign expenditure. In time, this also meant that Malta's shipping registry became one of the most sought after worldwide. Furthermore, for several years, Malta has boasted a strong ship-repair industry located in the heart of the Grand Harbour, an industry that has been run by a private Italian firm since 2010.

Grand Harbour and its four creeks – Rinella, Kalkara, French and Dockyard Creeks – is a natural port that was created through physical geographic processes that formed a ria, a submerged valley. It was probably shaped as a result of the sea level rise that took place in the Mediterranean Sea with the ice melting following the latest Ice Age. The Knights of St John took advantage of this natural formation: they built Valletta from scratch and consolidated the Three Cities (Cospicua, Senglea and Vittoriosa) around this port area: their bastions and fortifications served as the port's collective defence, while supplying human resources to support the burgeoning economic activity underway. Nowadays, the Grand Harbour also serves as a cruise ship terminal, passenger terminal for ferries to Sicily, a terminal for fast ferries to and from Gozo, marinas that cater for expensive yachts and super-yachts, water taxis and ferry services. Twice a year, on 31st March and 8 September, the harbour becomes the venue of boat races, known as the Regatta. The Regatta is a competitive rowing event that has been held in Malta since the middle ages.

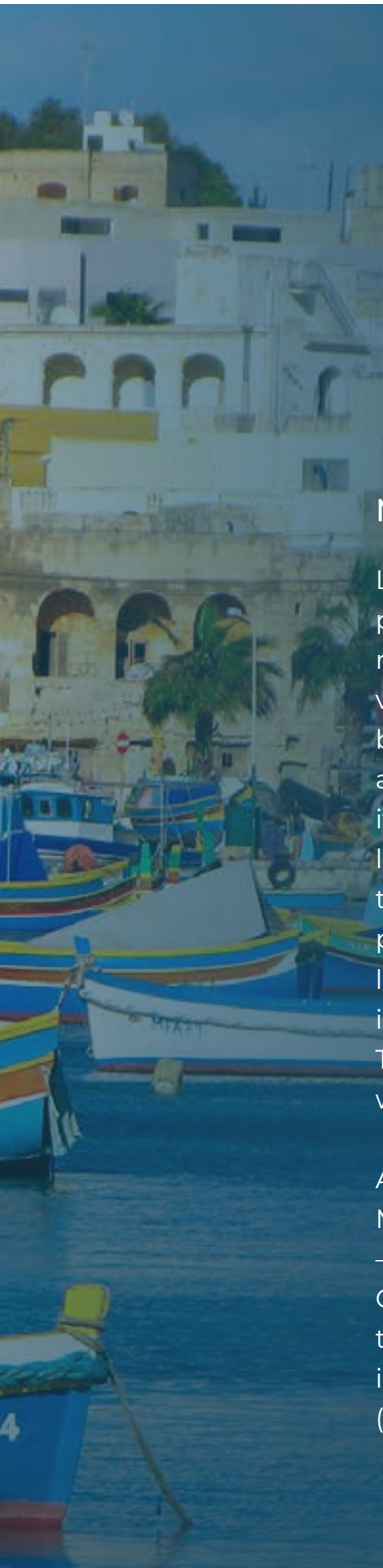
The ship repair industry and the Marsa Power Station have had a long-term negative impact on the Harbour environment, and which is now, hopefully, a thing of the past. Local residents have protested against the noise and fine particles emanating from sand and grit blasting that used to be carried out in the dock areas. And a shore-to-ship electricity system now allows cruise liners to benefit from a high voltage shore-based power supply, allowing them to cut off their engines: this stops the expulsion of boiler steam and smoke or engine exhaust while at port.

Ċirkewwa (Malta) and Mġarr (Gozo)

Another two ports of high interest to the local economy are Ċirkewwa and Mgarr Harbour, linking the islands with the main, Gozo Ferry service, which carries both passengers and vehicles. Tourists, locals, equipment and local goods – such as Gozitan agricultural produce – are transported between the islands through these two ports. This connection is vital for Gozo, Malta's smaller sister island, given its double insularity. In fact, tourism is a much more dominant industry in Gozo than in Malta, so connectivity is vital.

Mġarr Harbour – Gateway to the island of Gozo.

The colourful luzzu dominates the seascape at the fishing village of Marsaxlokk, SE Malta.



Marsaxlokk

Located in south-east Malta, the Marsaxlokk bay area is a sheltered port that was originally a fuel depot (at Il-Qajjenza) and a second-home residential area (at Birżebbuġa). Marsaxlokk itself is Malta's main fishing village, and whose shorefront is still dotted with the colourful Maltese boats. It is a site that is renowned for its traditional fishing activities, and the eye-catching luzzu, with the mystical eye of Osiris painted on its prow. A weekly Sunday morning market is also a popular event for locals and tourists. The headlands of the bay area function as the site of the Delimara Power Station, which replaced the heavy-fuel-oil-powered power station in Marsa. It was converted more recently to operate with liquid natural gas (An LNG tanker that serves as the station's fuel reservoir is anchored alongside). On the other side of the bay lies Malta Freeport Terminal, a busy hub for international cargo handling. The terminal's site was created after land reclamation.

Along the coastline of the Maltese Islands, it is at these four locations – Mġarr in Gozo; and Ċirkewwa, Grand Harbour and Marsaxlokk in Malta – that one comes across the unique hustle and bustle of port activity. Other than the (non-coastal) single airport in Luqa, these port areas are the lifelines that connect Malta to the world, responsible for almost all its imports (from food and tourists to equipment and fuel) and its exports (from manufacturing industry).

Cliffs[4]

Sephora Sammut

The Maltese archipelago, though small, is adorned with a rich tapestry of natural landscapes and landforms. Cliffs stand out as some of the most striking features of the Maltese Islands' coastal landscape. They account for nearly half the length of the total, national coastline. Steep cliffs are found along Malta's west, southwest and southeast coast, Comino's eastern and western sides, and most of Gozo's coast.

The spectacular cliffs at Dingli

The cliffs of each of the three populated Maltese Islands possess their own unique character. Yet, all offer unparalleled views and countless opportunities for capturing stunning photographs, memories and experiences. This chapter delves into the geological and geomorphological marvels of the coastal cliffs, highlighting these remarkable formations and the natural processes that shaped them, with a focus on four specific locations: Dingli Cliffs, Marsaskala and Munxar Cliffs (both in Malta), from Ta' Ċenċ Cliffs to Wardija Point (in Gozo) and the east and west cliffs of Comino. It also explores these cliffs' considerable ecological and historical significance.

Foundations (Geology)

Cliffs are embedded within the fabric of the Maltese geology which is characterised by a striking series of rocks that resemble a layered cake, each layer telling a part of the island's ancient geological history. The base and top layers are made up of the hard Lower and Upper Coralline Limestone, respectively. Then, layers of the softer Globigerina Limestone, Greensands and Blue Clay are sandwiched in between.

The cliffs that adorn the Maltese Islands are mainly characterised by the Lower Coralline Limestone and the Upper Coralline Limestone. The Lower Coralline Limestone, Malta's oldest rock formation, forms the foundation of many of Malta's towering cliffs, mainly along the west and south coasts of Malta and southwest Gozo. On the other hand, the Upper Coralline Limestone, the youngest formation, outcrops as steep plateaux delineated by jagged rock surfaces along particular cliff areas which formed by the dissolution of limestone.
In some areas, the retreat of the underlying Blue Clay causes the Upper Coralline Limestone above to sink, giving rise to a different type of cliffy landscape, that of scree slopes (MT: rdum). These slopes are marked by heaps of rugged, scattered rocks that have tumbled down from the Upper Coralline Limestone plateau due to slope failure. This distinctive landscape mainly features along Malta's northwest coast (such as around Ġnejna and Għajn Tuffieħa) and Gozo's east coast (such as the environs of Daħlet Qorrot).

Cliff development (Geomorphology)

The dramatic cliffs of the Maltese Islands owe their formation to tectonic forces, the natural processes which slowly push, pull and stretch the Earth's crust causing it to change shape over time. It is through tectonic activity, particularly faulting, that the main island of Malta is tilted, with high cliffs on the south and southwest coasts, and low cliffs (such as at L-Aħrax tal-Mellieħa and the south side of Mistra Bay) and rocky shores on the north and east coasts (such as Baħar iċ-Ċagħaq and Xgħajra). In fact, in Malta, the cliffs stretch almost uninterruptedly for about 40km: from Ċirkewwa in the north anticlockwise to Bengħisa in the south. In Gozo, the cliffs stretch around 20km: from Mġarr ix-Xini in the south clockwise to Wied il-Għasri in the northwest. In Comino, they are prominent on its west and east. The uplifting of the seabed and the subsequent erosion by wind and waves have sculpted the cliffs into their present form. The Upper Coralline Limestone plateaux act as the upland areas, especially towards the west of Malta. Such sculpting is a work in progress and continues unabated.

Snapshots of cliff formations

Dingli Cliffs

One of the most iconic cliff formations are the Dingli Cliffs, located on the western coast of Malta (near the village of Dingli). They are renowned for their breathtaking tiered cliffs, boasting views of the tiny uninhabited islet of Filfla, amidst the orange glow of sunset skies. Reaching up to 253m from sea level, Dingli Cliffs represent the highest point on the Maltese Islands.

The two sheer rock faces at Dingli Cliffs – the Lower Coralline Limestone base which reaches 120m, and the Upper Coralline Limestone plateau – are separated by the gentler slopes of the softer Globigerina Limestone and Blue Clay scree. Different forms of erosion weaken the upper plateau resulting in the collapse of parts of the cliffs, typically forming the inaccessible boulder screes. These screes create sheltered conditions for various indigenous flora and fauna species.

Below the screes, the landscape features patches of natural vegetation interspersed with terraced fields. The characteristic stepped terraces, divided by rubble walls to provide some shelter from the unforgiving wind and reduce surface water runoff during heavy rains, are testament to millenary agricultural practices. Moreover, the presence of freshwater from the perched water table once made it possible to farm even the lowest slopes. Over time, the hardships of cultivating steep terrain coupled with a dwindling supply of reliable freshwater, have led to the abandonment of many of these once-cultivated fields.

One of the most stunning viewpoints of the majestic Dingli Cliffs happens to be an area of archaeological value. The crossing of fault systems, availability of groundwater and the defensible nature of the Ġebel Ciantar promontory were well recognised by Bronze Age inhabitants, who acknowledged the tactical advantage to protect the landward side from potential enemy attacks. Today, nearly 4,000 years later, lies the ancient settlement of Wardija ta' San Ġorġ, its legacy etched into the landscape by the remains of a cyclopean wall, numerous silo-pit formations and carved rock structures.

Other landmarks of note at Dingli Cliffs are the St Mary Magdalene Chapel, the Dingli Radar, and the Coastal Surveillance Outpost, all located along the aptly named Panoramic Road. Evidence of the presence of the little chapel by the cliffs' edge dates back to the 15th century and indicates a legacy of engagement with the sea, whereby fishers at sea used the chapel as a point of reference. More recent additions include the Dingli Radar and the Coastal Surveillance Outpost, both established in 1939, when the British installed Malta's first Radar system. These landmarks are all testament to the strategic location of the cliffs shaped by natural forces.

Marsaskala and Munxar Cliffs

Nestled along the southeastern coast of Malta is the seaside town of Marsaskala, another gateway to some of Malta's limestone cliffs. In fact, the rugged coastline is delineated by straight cliffs, punctuated mainly by sea caves and rocky platforms: from il-Ponta tal-Miġnuna close to St Thomas Bay in the north through the Munxar headland, and to the Delimara peninsula further south.

These cliffs present a great contrast to the more familiar Coralline Limestone cliffs of Dingli and Ta' Ċenċ. This is because the entirety of the Marsaskala and Munxar Cliffs is carved out of the softer Globigerina Limestone, particularly the white-weathered Middle Globigerina Limestone. At Munxar, the height of the cliffs varies from

5m above sea level in some sections to over 40m in others. Waves acting on the friable rock, combined with surface gullies excavated by running water, are responsible for coastal erosion and the resultant cliff retreat, with several rock fall episodes from unstable fissures along the cliff face. The present condition of Ta' Riħama Battery – an artillery battery from the era of the Order of St John constructed to safeguard St Thomas Bay – with sections having crumbled into the sea, reveals the relentless power of the sea.

Further south of the Munxar headland, in the environs of Xrobb l-Għaġin, the Middle Globigerina Limestone is topped by the younger Upper Globigerina Limestone. The cliff face displays a striking ribbed pattern, with pale grey and cream-coloured layers reflecting alternating bands of harder and softer rock. This distinct appearance hints at fluctuating environmental conditions during the limestone's formation. The varying shades of colour within the strata along the cliff face reveal zones of particular vegetation, which possibly thrive due to water percolation that supports plant growth.

From Ta' Ċenċ Cliffs to Wardija Point

Heading now to Gozo, we must start with the imposing cliffs at the locality known as Ta' Ċenċ (near the village of Sannat). These dominate the southeastern rugged coast of Gozo, and they owe their imposing beauty to the Lower Coralline Limestone which has weathered into near vertical faces. These 4km-long cliffs rise to heights of around 140m, reflecting the thickest exposure of the Lower Coralline Limestone on the Maltese Islands.

The parallel bedded horizons of the Lower Coralline Limestone are clearly pronounced at Ta' Ċenċ, particularly in the inaccessible vertical cliff sections. The cliff base is chiselled with many sea caves, formed by incessant wave action; whilst the plateau overlying the cliffs has been formed by the receding softer Lower Globigerina Limestone.

The path along the cliff edge, running from the Ta' Saguna Cliffs to Is-Sanap Cliffs and which reaches the seaside village of Xlendi, makes for a very rewarding off-the-beaten-track experience, full of viewpoint spots. The track leads past farmland, uncultivated fields and garrigue habitats, the latter dominated by low-growing, hardy and often aromatic wild plants thriving in patches of soil amidst rocky terrain. Xlendi itself has been recognised since Roman times as a natural harbour, a secure refuge nestled within high enclosing cliffs. Another panoramic cliff path is that which leads from Xlendi to Ras il-Wardija, the southwestern tip of Gozo. Here, at the wind-swept isolated promontory of Ras il-Wardija, is a Roman-Punic Sanctuary, a cave directly facing the open sea, which was hand-excavated out of the yellow Globigerina Limestone more than two thousand years ago.

For those seeking a mesmerising sunset as it sinks below the horizon, the cliffs of Gozo offer an excellent vantage point. In the heat of summer, one can bask in the view from the towering cliffs of Xlendi. As autumn approaches, one can head further south to the secluded headland of Ras in-Newwiela, just before the start of Ta' Ċenċ cliffs (and not far from Mġarr ix-Xini Bay). During the winter months, the majestic Ta' Ċenċ Cliffs themselves provide a breathtaking backdrop for sunset.

Comino

The islet of Comino is famous for its crystal-clear waters and rugged coastline. Its dramatic rocky cliffs, especially on the western and eastern facing sides, may not be as high as those of Malta and Gozo; but they are still worth a mention.

The Upper Coralline Limestone makes up the entire land surface of Comino. Tectonic tilting produced the gentle sloping shores along the island's north and northwest coast and the opposing plunging cliffs on the west and east coast. The exposure of the cliffs to wave action sculpted the rockface through cliff retreat, forming numerous sea caves, natural arches and tunnels.

On the east coast, whose cliffs rise to almost 75m, the presence of the underlying Blue Clay formation below sea level destabilised the overlying Upper Coralline Limestone. This is evidenced by the numerous rocks which dot the coast, forming boulder screes.

The ecological value of Malta's cliffs

The cliffs of the Maltese Islands are more than just geological marvels. They serve as vital ecological sanctuaries. The steep inaccessible terrain of cliffs offers a relatively less disturbed habitat for a diverse array of plant and animal species. It is no surprise that both the Maltese Islands' national plant, the Maltese Rock Centaury, and the national bird, the Blue Rock Thrush, call cliffs their home.

Moreover, much of the cliff areas are designated as Special Protection Areas and/or Special Areas of Conservation of International Importance, forming a crucial part of Malta's Natura 2000 network of protected areas under the EU Nature Directives.

Wild Flowers

The typical flora which thrive in cliff environments (rupestral) are hardy plants that are adapted to withstand the plant-hostile, wind-exposed and sun-drenched crevices and cavities within limestone cliffs.

Rupestral plant communities consist mainly of shrubs that tolerate the salty conditions imposed by the vicinity to the sea, including numerous naturally occurring endemic species which are restricted to cliffs. Some of these rare endemic plants are paleo-endemics, relics from pre-glacial Mediterranean times. These include the Maltese Cliff-Orache (*Cremnophyton lanfrancoi*), Maltese Rock Centaury (*Palaeocyanus crassifolius*), Maltese Salt-Tree (*Darniella melitensis*), the Maltese Fleabane (*Chiliadenus bocconei*), Maltese Hyoseris (*Hyoseris frutescens*) and the Maltese Everlasting (*Helichrysum melitense*). The latter two rupestral species are only found in Gozo.

Where the upper plateau is covered by garrigue vegetation communities within outcrops of bare rocks such as at Dingli Cliffs, low aromatic small-leaved shrubs and herbaceous spiny plants thrive. These include the Mediterranean Thyme (*Thymbra capitata*), Maltese Yellow Kidney Vetch (*Anthyllis hermanniae subsp. melitensis*), Mediterranean Heath (*Erica multiflora*) and several wild orchid species.

The white Munxar Cliffs, limits of Marsaskala.

Fauna

The crevice s and ledges of cliffs provide vital habitats for birdlife, whether for resting, feeding, breeding and or/nesting. These rugged niches are especially valued by seabirds, which seek out these remote and inaccessible locations to evade predators and human disturbance.

Many of the cliffs' natural holes and crevices offer adequate habitats to breeding colonies of the common Yelkouan Shearwater (*Puffinus yelkouan*) and the Scopoli's Shearwater (*Calonectris diomedea*). From February to March, the eerie, ghostly calls of the Yelkouan Shearwaters echo through the cliffs, marking their arrival. Meanwhile, the Scopoli's Shearwaters establish breeding colonies along the cliffs between March and October. Ta' Ċenċ Cliffs, in particular, host the largest concentration of Scopoli's Shearwaters in the Maltese Islands and are home to a small colony of Mediterranean Storm-Petrels (*Hydrobates pelagicus melitensis*). These small seabirds come ashore in late March during the breeding season. The three seabird species only approach their nesting sites along crags in the inaccessible cliffs under the cover of darkness. Sadly, they are vulnerable to light and sound pollution stemming from human activity. The Blue Rock Thrush (*Monticola solitarius*) is also confined to coastal cliffs, favouring crevices for nesting and rocky areas for feeding. The local resident population is fairly abundant, with individuals present along all the cliffs of the north and west coasts of mainland Malta, and along the coasts of Gozo and Comino. The open grounds atop cliffs sometimes favour the nesting of the ground-dwelling Short-toed Lark (*Calandrella brachydactyla*), which is a common migrant and summer breeding visitor.

A rich variety of reptiles, insects and small mammals are nurtured by cliff environments. Quite commonly encountered reptiles in the garrigue habitats within the environs of cliffs are the Maltese Wall Lizard (*Podarcis filfolensis maltensis*), Moorish Gecko (Tarentola mauritanica), and the Ocellated Skink (*Chalcides ocellatus*). Moreover, the largest and most common snake in the Maltese Island, the Western Whip Snake (*Coluber viridiflavus carbonarius*), is frequently spotted along the open rocky ground atop cliffs. In contrast, one of the rarest animals in the Maltese Islands, the endemic Maltese Door-Snail (*Lampedusa melitensis*) is confined to the southwestern cliffs of mainland Malta. As for mammals, bats have been recorded along cliffs, particularly in areas where caves are found.

Maltese coastal cliffs serve as valuable sites for geological, geomorphological, ecological and historical endeavours. Apart from providing habitats for plants and animals, cliffs serve as popular destinations for different types of recreational activities and tourism. During the cooler months (October to May), when the weather is more favourable for outdoor activities and the countryside is lush with vibrant shades of green, these cliffs become particularly attractive for hiking and trekking enthusiasts. There are also a number of informative hubs that offer engaging ways to learn more about these stunning areas. They include The Cliffs Interpretation Centre atop Dingli Cliffs, the Xrobb l-Għaġin Nature Park and Sustainable Development Centre between Marsaskala and Marsaxlokk, and Dwejra Marine Environmental Education Centre in Dwejra (limits of San Lawrenz) Gozo.

Finally, a word of caution. Whilst the cliff tops offer awe-inspiring views, the risks should not be underestimated. Always keep a safe distance from the cliff edges. Watch your step, since the terrain is likely to be uneven. And be careful not to overstep on the natural vegetation, whilst still savouring the breathtaking vista from designated viewpoints.

Lighthouses

Ruben Paul Borg

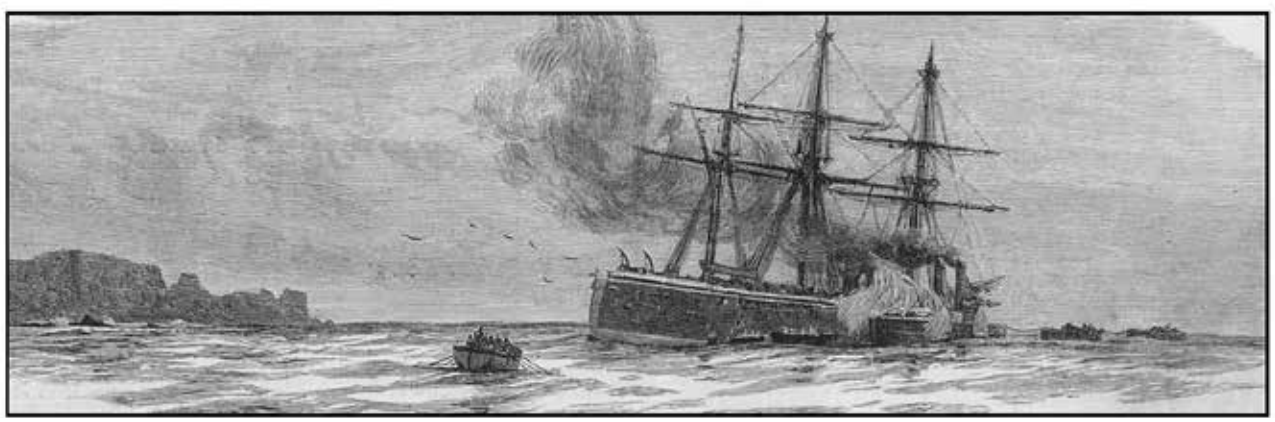
The Grand Harbour breakwater lighthouse at the Ricasoli side.

Introduction: Of storms and shipwrecks

On 6th March 1889, HMS Sultan, a Victorian ironclad vessel, ran aground on an uncharted rock some 500 metres from shore, off the South-eastern coast of Comino in the channel between Malta and Gozo. The bottom was ripped open, and she started to take on water. A number of Royal Navy vessels were deployed to assist; however, all attempts to pull her off the rock failed and, during a gale on March 14th, she slipped off the rock and sank. She was raised in August by the Italian firm of Baghino & Co for a fee of £50,000, and then towed into the Malta Dockyard for preliminary repairs. She made the passage back to Portsmouth in December 1889. The grounding of HMS Sultan was well covered in the British and international press. This was not, however, an isolated ship grounding incident in Malta's eventful maritime history spanning centuries.

The Maltese Islands are strategically located, with key sea routes crossing their waters, linking the main ports of the Mediterranean basin. The archipelago has been colonised for centuries with its natural harbours well exploited over time, and an intense maritime activity is well recorded; for example, through the quarantine and arrival register (1770-1815) with systematic records of numerous ships arriving in Malta.

The Maltese coasts are seasonally affected by extreme storms with frequent heavy seas and waves mostly originating from the North-East (Gregale) and North-West. There is evidence of shipwrecks dating back at least to the Phoenician and Roman periods. St Paul's Shipwreck, recorded in the Acts of the Apostles (27–28) during his journey to Rome in the first century CE, is intimately linked to Maltese religious tradition and culture and is arguably one of the most important and consequential extreme weather events in the Maltese Islands. Traditionally, St Paul's Islands at Selmun have been defined as the location of the shipwreck. The Islands are reported for another shipwreck when, in 1576, Marco di Maria was being chased by barbary corsairs off the Maltese coast and navigated his vessel through the narrow channel between St Paul's Island and Malta. When the pirates followed him, they ran aground and were captured. Yet, the location of St Paul's shipwreck is disputed: it is argued that, given also the prevalent North Easterly winds, the shipwreck possibly took place in the south east coast of Malta, in an area known as il-Munxar with a submerged reef and a sandy beach at St. Thomas Bay. It is argued that archaeological evidence of sea anchors in St. Thomas Bay, the toponyms in the area and the chapel of St Paul at Xrobb l-Għaġin further support this thesis. Indeed, the reefs in the Marsaskala area were the location of a major wreck, when on the 23rd of September 1969, the tanker Angel Gabriel drifted onto a reef there during a strong



Grounding of HMS Sultan near Comino in the channel between Malta and Gozo (The Graphic)

gregalata. The danger posed by reefs around the Maltese Islands is evident also from other major incidents, such as the MV Star of Malta carrying passengers and a deck cargo of fruit, which was shipwrecked at the Merkanti reef off Dragonara Point on 29th July 1955.

These wrecks highlight the importance of reference landmarks on the coast to guide mariners. Over the centuries, coastal watch towers constructed for the defence of the coast are known to have served as key landmarks for mariners. The Tal-Ħamrija Tower (Torre della Pietra Nigra, Red Tower in Mellieħa) constructed in 1647 is at a vantage point above Mellieħa Bay, maintaining a good communication between Gozo, Comino and Mdina. The Tower, with its distinctive red colour contrasting with the surrounding landscape, is recorded to have been considered as a landmark for shipping.

Malta provided a secure base for the British fleet in the Mediterranean during the nineteenth and twentieth centuries. Eventually, the development of Malta as a British military base resulted in increased maritime activity in Maltese waters and its ports, with the consequent strengthening of coastal infrastructure and defence. It is with this backdrop that lighthouses as distinctive structures, were planned and constructed in the Maltese Islands during the 19th Century.

Lighthouses in Malta

Lighthouses were constructed as tall towers typically located close to the perilous rocky shore (as in the case of the Delimara Lighthouse), or on high ground (as in the case of Il-Fanal tal-Ġordan, Gozo), allowing for a bright light at the top with a large or magnifying mirror mechanism, to present a warning to ships navigating Maltese waters, and guiding them safely.

Mariners approaching Valletta and entering the Grand Harbour and Marsamxett at the end of the 19th Century, would have seen a significantly different view to the one that greets them today. In the 19th Century, lighthouses were also located at the entrance of the main ports at Grand Harbour and Marsamxett, with structures erected at Fort St Elmo Valletta, at Fort Tigne and at Fort Ricasoli. At the time, an imposing lighthouse stood at the edge of one of the angles of Fort St Elmo, while a cylindrical lighthouse stood at the entrance of the Grand Harbour within Fort Ricasoli. Similarly, a lighthouse stood next to Fort Tigne, on the other side of Marsamxett Harbour. These three lighthouses no longer exist: they were dismantled due to changing exigencies and changing costal and harbour infrastructure. At the beginning of the 20th Century when the breakwater of the Grand Harbour was constructed, lighthouses were erected at the tip of the breakwater arms, next to Fort St Elmo and Fort Ricasoli respectively, guiding ships safely into and out of the harbour.

Today, two main lighthouses survive in the Maltese Islands: the Ġordan Lighthouse in Gozo and the Delimara Lighthouse in south-east Malta, complete with keeper's quarters, besides the breakwater lighthouses. Other secondary yet important structures, such as those at Ċirkewwa (NW Malta) and Mġarr (Gozo), also guide mariners in accessing the harbours and berths safely.

The Lighthouses at Marsamxett and the Grand Harbour

Fort St Elmo Lighthouse (Demolished)

The Lighthouse at Fort St Elmo was a distinctive landmark of 19th Century Valletta. In 1838, GP Badger reported that "the lighthouse which rises from one of the angles [Fort St Elmo] has lately been improved by the English Government". It is reported to have been c. 17 metres high, set on the bastions with its base more than 30 metres high above sea level, guiding ships approaching and entering harbour. Lighthouse keeper's quarters were located close to the lighthouse with recorded alterations and additions up to the 1920s. The lighthouse was demolished in 1940 for security reasons, as it presented an undesirable landmark for enemy action during World War II. Its base is all that remains within Fort St Elmo.

Tigne Torre Del Fuoco (Demolished)

The Tigne lighthouse, referred to as the Tigne Torre del Fuoco, was constructed in the 19th century. It consisted of a circular stone tower with an internal stone spiral staircase reaching the top, with the lighthouse keeper's quarters at the base. Alterations and additions at first floor to the keeper's quarters are recorded in 1865 and evident in historic photos. A new light house, Southwest of the Torre del Fuoco, with a rectangular plan is recorded in a drawing dated 1904, with construction of an extension at first floor dated 1935. An additional archive detailed drawing of the second lighthouse includes a note stating, "destroyed by enemy action".

The lighthouse at Tigne Point (now demolished) (19th century photo) (Richard Ellis Collection).

Ricasoli Ports Lights Building (Demolished)

A "building to be erected... for the purpose of exhibiting port lights at Fort Ricasoli", was proposed in drawings dated 1858. The stone tower located at the north-west corner of the Fort, had a circular plan with a spiral staircase within and with two apertures including one at the top to exhibit lights. The lighthouse keeper's quarters were eventually constructed at its base and drawings dated 1884 indicate the construction of an additional floor to the keeper's quarters. Furthermore, drawings dated 1902, indicate additions to the keeper's quarters and the installation of a self-registering anemometer and wind vane. The drawing further indicated red lights at the two apertures of the tower. The latter archive drawing also indicates the proposed new breakwater on the side of Fort Ricasoli, suggesting the interventions to the Ricasoli Lighthouse during the construction of the breakwater.

The lighthouse in Fort Ricasoli prior to the construction of the Grand Harbour breakwater (19th century photo) (Richard Ellis Collection).

The Grand Harbour St Elmo Breakwater and Ricasoli Breakwater Lighthouses

Grand Harbour is a natural port with a number of inlets which provide adequate shelter to naval vessels. However, it had one particular drawback: it was not an all-weather port due to its exposure to north and north-easterly winds. With the increasing strategic importance of Malta as a British naval base during the 19th century and as a port of call for ships en route to India, the need was recognised to transform Grand Harbour into a year-round port. In February 1890, the British Admiralty then commissioned civil engineers Messrs Coode, Son and Matthews to draw up plans to construct a breakwater at the entrance of Grand Harbour.

Since Grand Harbour was exposed to the north-easterly Gregale wind, the engineer's brief was to render the entire harbour usable when the strong and stormy Gregale wind blew at its most furious, without impeding the circulation of water. The distance between the breakwater arms had to allow the largest warships to enter safely but at the same time protect the harbour against the north-easterly wind. The design proposal included a 378-metre arm at Fort St Elmo, following a slightly curved line along Monarch's Shoal, a 122-metre arm at Fort Ricasoli, a spur pier at the base of Il-Ponta ta' l-*Imgerbeb* (not constructed) and the levelling down of the rocky shore along the bastions to form a

St Elmo Breakwater Lighthouse and adjacent lighthouse keeper's quarters.

wave trap. The Grand Harbour breakwater was constructed between 1902 and 1909, as a means of protection against bad weather; but also, to provide a defensive barrier against a potential naval attack on Grand Harbour. Therefore, the completed breakwater incorporated a wall offering protection against north-easterly storms, a dog-leg steaming course and a boom defence against naval attack, with an enlarged anchorage for vessels within the harbour. The breakwater arms consist of precast concrete blocks bonded together to form an almost vertical gravity barrier wall 11.4 metres thick and up to 14 metres deep, designed to resist the powerful wave action caused by the Gregale. The layout of the arms was also intended to allow for a system of floating steel boom defences with anchorage chambers hidden in the St Elmo breakwater arm and the tip of the Ricasoli arm. A precast concrete block production yard was set up at Mistra, supplemented by coralline limestone aggregate from quarries in Qala, Gozo. Hardstone was also used for the cladding of the breakwater above the level of the sea, the creation of an access stairway at St Elmo and the external walls in the construction of the lighthouses. The concrete blocks cast at Mistra, including those forming the base of the lighthouses, were transported by barges to Grand Harbour and lowered into place using cranes. Vertical precast concrete dowels were used to join the blocks, with horizontal dowels used to resist horizontal movements, resulting in a homogeneous barrier. The longer arm of the breakwater is detached from the shore at St Elmo, with a 70-metre gap. The gap allows for the circulation of seawater. In 1906, a two-span iron footbridge was constructed to provide access from the shore to the breakwater and the lighthouse. The footbridge consisted of two spans each measuring 34.4 metres, perched on central supporting structures consisting of cylindrical iron columns with concrete infill. The bridge structures had a width of 6.4 metres and a height of 4.8 metres, with the main elements of the bridges consisting of two trusses with

arched top chords and timber decking. In 1941, during the Second World War, the footbridge was partially destroyed in an Italian naval attack and eventually the bridge structures were removed. The central cylindrical supports were retained but one of them was carried away during a storm in December 1991. The St Elmo breakwater and its lighthouse remained isolated until a new steel footbridge was constructed in 2012.

The St Elmo Breakwater Lighthouse drawings indicate different alterative options including an option with the lighthouse keeper's quarters following a circular plan at the base of the lighthouse. The lighthouse was eventually constructed, with adjacent lighthouse keeper's quarters based on a rectangular plan. A tunnel runs the entire length within the breakwater reaching the keeper's quarters and the base of the lighthouse. The 14m high lighthouse includes a lantern at the top and was constructed with a cast mass concrete core and external hard stone blocks, to withstand the extreme coastal environment and wave action. The Ricasoli Breakwater lighthouse is smaller than the St Emo Breakwater lighthouse, having a height of 9m. The focal plane of the St Elmo Light is 16 m with quick-flashing green light, whereas the focal plane of the Ricasoli Light is 11 m with quick-flashing red light.

The former lighthouse at Fort St Elmo. It was demolished in 1940 for security reasons, thus avoiding its use as a landmark for enemy aircraft during World War II.

The Ġordan Lighthouse (il-Fanal tal-Ġordan)

The Ġordan Lighthouse was constructed in 1853. It consists of a two-storey stone building which served as the lighthouse keeper's house, with the white painted lighthouse stone tower and lantern towering up to c. 22m. The 1852 drawings of the lighthouse indicate smaller keeper's quarters; but it is evident that extensions and additions were proposed, as demonstrated in archive drawings dated 1853. The lighthouse at Ġordan hill does not only serve as an aid to navigation but also as the Global Atmospheric Watch Station for the Central Mediterranean. Its light has a focal plane of 180m, flashing white every 7.5 seconds and visible for 20 nautical miles. The Ġordan lighthouse serves as the main light for ships approaching Malta from the western Mediterranean.

The Ġordan Lighthouse (Richard Ellis Collection)

The Delimara Lighthouse

The Delimara Lighthouse was commissioned by Governor O'Ferrall in 1850, with construction initiated around 1854 and it was functional by 1855. It is located at the south-east end of Malta and consists of a two-story rectangular block and a central octagonal tower, with extensions constructed during the 19th century. The lighthouse was constructed with Globigerina limestone blocks, and with hardstone used for the upper courses of the coping which secures the lantern housing. The lighthouse sustained damages during World War II, with shrapnel on the outside elevations and breakages to a number of glass panes. The lighthouse originally had a static red lantern; but in 1896 it was replaced by a more powerful gasoline lamp which was operated by a hand-wound mechanism which produced beams of alternating red and white light flashing at intervals of 30 seconds. Its arc of visibility ranged from 19 degrees to 295 degrees, with a radius spreading up to 15 miles. The focal plane height is 45 metres. The Delimara lighthouse served as a landfall light for ships approaching Malta from the East, while marking the north entrance of the Marsaxlokk harbour.

In 1950 it was decided to paint the outside of the tower in black and white stripes for mariners to recognise it immediately. In 1956 it was reported that the mechanism was defective and that it had a tendency to stall. The lighthouse was decommissioned by 1990, and an automated light source was placed on an adjacent two storey building, with a focal plane of 35m, emitting two white flashes every 12 seconds with a range of 18 nautical miles.

The Delimara lighthouse is the only one in Malta to be equipped with Fresnel lenses. Fresnel produced six sizes of lighthouse lenses, divided into four orders based on their size and focal length. Delimara lighthouse is equipped with a lens very close to that of a third-order and with a focal length of 530mm and a height of 1.6m. The British Glass factory, Chance

Brothers Ltd, adopted a revolutionary design by fixing the Fresnel lens on a rotating table and with the light source at the centre. The rotation of the lenses around the light source thus produced light beams that appeared as light flashes from out at sea. By using transparent and coloured lenses and using different rotation speeds, each lighthouse had its own distinctive light pattern, generally known as the 'Lighthouse Signature'. In the Delimara lighthouse, the table rotated by a mechanism, similar to that of a clock driven by a weight hanging from the very top of the lighthouse which unwinds the drum of the mechanism and turns the gear train, once released. The light source at the Delimara lighthouse was provided by a pear-shaped paraffin tank made of copper.

The St Elmo and the Ġordan lighthouses used a different system to the one at Delimara. A schematic diagram reported to having been found at the Lighthouse keeper's room at Tal-Ġordan shows that it consisted of 21 reflectors mounted on a triangular rotating base, with seven reflectors on each side, and with each reflector having its own oil lamp complete with tank. Archive documents reveal that the lighthouse keeper at St Elmo used to share spares with Tal-Ġordan lighthouse, suggesting similar if not identical light systems. The 1907 section plan of the Ġordan Lighthouse confirms that the lighthouse used a number of reflectors to produce the light beams. The Delimara lighthouse was transferred to Din l-Art Ħelwa in 2006 and restored, with functional light, though not in operation.

The Delimara Lighthouse

Other lighthouses in Malta and Gozo

Mġarr Harbour lighthouse

A first breakwater was constructed at Mġarr Gozo in 1841. The construction of a new breakwater commenced in 1929, and works were completed in 1935. A concrete lighthouse was proposed in 1933 Its design included 20cm thick cast concrete walls, with a circular 2m diameter plan, tapering up and reaching an overall height of 5m. The lighthouse design included internal wall-mounted ladder rungs to reach the light at the top.

The port was further expanded and a new larger breakwater at Mġarr was constructed in 1969. This included a 5m high conical concrete tower mounted on a cylindrical base with painted red and white bands at the tip of the main breakwater, with lights having a focal plane of about 8m with a red flash every 4s. A second similar lighthouse painted with green and white horizontal bands is located at the tip of the north breakwater, with lights having a focal plane of about 7m with a green flash every 5s.

Mġarr Gozo Harbour

The Ċirkewwa lighthouse

The Ċirkewwa lighthouse located at the end of the rocky promontory is exposed to an aggressive marine environment with risk of degradation. Towering above the ferry terminal, the lighthouse has become a distinctive feature over the past decades. It consists of a reinforced concrete tower structure, standing on a wider conical concrete base rising from the coastal rocks. The upper part of the structure is reached from within the lighthouse keeper's rooms located at the base, through a wall-mounted ladder, or through an external staircase, a characteristic feature which curves up around the base of the upper tower of the lighthouse.

The Ċirkewwa lighthouse

The Light at Fort San Luċjan

Fort San Lucian in Marsaxlokk is located on the coast, with a foreshore immediately below its walls. A 1900 drawing further presents Wigham's 31-day Buoy Lamp for installation at Fort San Lucjan, while the installation of Leading Light on the shore platform under the Fort is recorded in a 1901 drawing. Furthermore, fixed white lights are recorded at 40 metres above average sea level, in drawings dated 1933. These installations, though not lighthouses, still demonstrate the danger posed by reefs and shore platforms and the preoccupation with marking them for mariners.

Conclusion: Beacons

With developments in engineering and satellite technology, mariners today have new tools enabling safe navigation. Access to technology ensures safe passage of ships in Maltese waters. The lighthouse structures, however, are and reman beacons of our country's rich history, testimony of the importance of the Maltese Islands as a safe port in the middle of the Mediterranean sea, through the ages. The lighthouses, the engineering structures and mechanisms, define heritage values and inform their conservation as important monuments and landmarks. They stand as proud sentinels of the sea and reference landmarks to mariners.

The lighthouses' unique locations and structural systems, today present opportunities in their conservation and adaptive reuse, as heritage buildings but equally as interpretation centres, and as environmental or coastal engineering monitoring stations. The beacons which served and guided mariners in past centuries, reach far in the quest of science and engineering research, towards new frontiers.

Coastal Towers

Stephen C Spiteri

Coastal watchtower at Għajn Tuffieħa.

For most of the time that the Maltese archipelago was inhabited, its inhabitants had no choice but to look apprehensively over their shoulder: the islands are small, there are no formidable hills or mountains inland that would serve as a natural place of safety and refuge. The chances of an invasion by sea were likely and permanent, especially in the long summer months. Other than the central fortified towns of Mdina and the castles in Gozo and Birgu, there were no walled settlements that could afford any measure of protection against marauding invaders, mainly corsairs, intent on plunder or snatching locals as slaves; and even these walled features were attacked at times.

With the arrival of the military order of the Knights Hospitaller of St John to Malta in 1530, however, things slowly started to change. After the devastating raid on Gozo of 1551 and then the 'Great Siege' of 1565, where a strong Turkish army and navy were repulsed after an arduous four-month investment, the Knights' main concerns and overriding strategic priorities were to erect a new fortified city and to protect the adjoining Grand Harbour. This was a massive undertaking which absorbed all of the Order's resources. By the start of the 17th century, however, the countryside outside of the fortified urban core inside the Grand Harbour area, together with most of Malta's farm holdings and rural settlements, remained wide open to attacks from the nearby sea. And with a growing resurgence of Ottoman incursions into the western Mediterranean, the problem of securing the Maltese Islands' shores against corsair raids could no longer be ignored

Indeed, in all the other places along the shores of the Mediterranean, the Knights' Christian allies had long been busy bolstering defences: along the coasts of Sicily, Southern Italy, Sardinia, Majorca, Minorca, and the Spanish mainland, hundreds of small coastal forts and watchtowers were erected. Sixteenth-century documents and records of the Knights of St John fail to reveal any debate on the issue, except for one which revolved around the need for a tower on the small island of Comino, situated between Malta and Gozo: an unresolved matter that went back to the Middle Ages. In fact, in 1533, the Knights had to suffer the indignity of witnessing this small unfortified island being used by corsairs to shelter their galleys as they lay in ambush for unsuspecting vessels sailing to and from Sicily. Again, in 1574, some 300 Turkish vessels sheltered in the Comino channel for four days with total impunity before moving on; in 1582, a Turkish fleet was sighted sailing just off the island; and in 1583, four galliots from Bizerta raided Gozo, sacked its settlement of Rabat, and carried off seventy of its inhabitants into slavery.

For most of the time. the Knights' galleys generally managed to keep most marauding Turkish vessels away from the islands' shores. But their small fleet could not always be counted upon to patrol the seas, particularly during the open season when the Order's galleys were often away raiding the Eastern Mediterranean. The shores of the Maltese islands, with their many bays and landing places, were simply inviting to corsair incursions. The absence of coastal defences only served to aggravate the situation.

The Knights of St John were convinced of the need to set up valuable look-out posts with which to keep a watchful eye on naval movements; but the Order simply had no money for coastal towers and defensible watchposts. So, when the Knights did finally decide to take the matter in hand, it was only possible thanks to the personal contributions of various Grand Masters who financed these works out of their own pockets.

The first Grand Master to do so was Martin Garzes (ruled 1595-1601), following the defence emergency of 1598, caused by the sighting of over 40 enemy vessels off southern Sicily. On that occasion, the Italian military engineer

Giovanni Rinaldini da Ancona was quickly invited to Malta to help the Knights reorganize Gozo's defences. Apart from highlighting the need for the construction of a new bastioned fortress to improve Gozo's old castle, Rinaldini also called for the erection of a coastal tower at Mġarr harbour for the purpose of guarding the channel between Gozo and Comino. Grand Master Garzes did not live long enough to see the implementation of the scheme; but he left enough money in his will, to the tune of 12,000 scudi, to guarantee the tower's construction, which was eventually named after him (Garzes Tower). It fell on his successor, Grand Master Alof de Wignacourt (ruled 1601-22), to see to its erection in 1605. Wignacourt, however, went further, and invested his own money in the construction of a series of additional, powerful coastal towers. These were large, squarish, solid structures, capable of mounting batteries of heavy guns on their roofs and were garrisoned by sizable detachments of troops in times of emergencies. Five such towers were built: at St Paul Bay (1609/10), Marsaxlokk (St Lucian Tower – 1610), Marsaskala (St Thomas Tower) (1614), Comino (St Mary's Tower – 1618), and Santa Maria delle Grazie at Xgħajra (1620 – demolished in 1888 by the British military to make way for a new coastal fort). A sixth tower, built at Marsalforn, Gozo in 1616 (referred to as Marsalforn Tower) was paid for by either the Gozo Universita' or the Order itself.

Apart from their massive size, the characteristic feature of these large towers, or fortini, was their corner turrets, rudimentary bastions designed to allow a degree of close-in flanking fire, as well as their large barrel-vaulted interiors, designed to withstand both the weight of a sizable number of cannon mounted on roof batteries, as well as to absorb a great deal of punishment from enemy bombardment. The only exception was the Marsalforn Tower: this was not fitted with corner turrets.

The huge costs that went into the building of these massive sturdy works, however, led to a preference for smaller structures which were designed to serve largely as an early-warning system so as to alert the Knights and the population, of the approach of hostile enemy vessels. These watch-posts would house the militia coast guards who, up until then, had performed their night-watch duties either out in the open or from the refuge of small unfortified rural buildings or other makeshift sentry rooms. The first seven such towers were built by Grand Master Jean Paul Lascaris Castellar (ruled 1636-57). Six of these were coastal and were erected at: Għajn Tuffieħa, Lippija, Blat Mogħża, Qawra Point, St George's Bay and Wied iż-Żurrieq. The only inland tower was erected at Nadur (l/o Binġemma) in 1637.
The design of these watchtowers reflected a marked departure from the massive structures built earlier. They were each about 11m high and 36m2 in base plan. Internally, each consisted of two single-room storeys, with external access provided solely to the upper floor, reached either by a ladder made of wood or rope. The only exception was the Red Tower in Mellieħa (also known as Torre Rossa, Fort St Agatha), which was built in 1647-49 in the manner of the bastioned towers erected earlier during Wignacourt's reign.

The six Lascaris coastal watchtowers were augmented by another 13 towers erected in Malta in 1658/59 at the expense of Grand Master Martin de Redin (ruled 1657-60). These were built at: L-Aħrax tal-Mellieħa, Għajn Ħadid, Għallis, Qalet Marku, Madliena, St Julians, Triq il-Wiesgħa, Żonqor Point, Xrobb l-Għaġin, Delimara, Bengħisa, l/o Żurrieq, and Ħamrija. Although similar in design, these de Redin towers were more sturdily built than their Lascaris predecessors and capable of bearing the weight of mounted cannon. Altogether, the design of these watch towers was heavily influenced by the towers developed in nearby Sicily during the later part of the sixteenth century, particularly those standardized by the Florentine Camillo Camilliani, with their distinctive rectangular form with inclined bases and vertical articulation on several storeys. Such towers were solidly built in

Tal-Ħamrija Tower near Qrendi was built in 1659.

masonry, with barrel vaults and protected by thick walls devoid of apertures on their ground floor level. They had their main entrances opening on the first floor, only accessible by retractable ladders. The first floor in each tower served as the living quarters.

A parallel investment in coastal defences was undertaken in Gozo. There, a further six towers, built much sturdier than their Maltese counterparts, were erected. The first was at Mġarr harbour in 1605; followed by Marsalforn Tower in 1616; and those erected at Mġarr ix-Xini, Dwejra, Xlendi and Nadur, around the middle of the century; and, finally, by a new tower at Marsalforn, built in 1720 to replace the earlier structure which had fallen into disrepair. This, however, was more of a tower-redoubt and was erected a considerable distance inland on the plateau.

By the mid-1700s, the Knights had some 34 towers guarding the shores of the Maltese archipelago. By that time, however, they had moved on from a dependence on towers to a more elaborate and extensive system of coastal gun batteries, redoubts and entrenchments designed to resist and repulse an invading enemy force at the point of landing. Several of the existing towers, nevertheless, were brought into this scheme in 1715 and fitted with external gun-platforms and enclosed by defensive walls to serve as small defensible coastal forts. The best surviving examples of these can be found at St Thomas Tower, St. Julian's Tower, L-Aħrax Tower (Mellieħa) and Qawra Point Tower.

Fortunately, a large number of the Knights' coastal towers have survived and can still be seen dotting the islands' coastline today. In all, around 10 towers (29 %) have been lost or have been reduced to a state of archaeological ruin over the passage of time. Two of these – the Marsalforn Tower (1616) and the Blat Mogħża Tower (Torre Capra) – were dismantled by the Knights themselves after these had fallen into ruin owing to the fissuring of the cliff faces on which they were built. The Għajn Ħadid Tower lost its upper storey during the earthquake of October 1856. Delimara Tower, Garzes Tower, Santa Maria delle Grazie, and the second Marsalforn Tower were demolished by the British military. And the towers at Żonqor Point, Bengħisa and Xrobb l-Għaġin fell into decay and ruin.

Of the surviving towers, around 18 have been restored and are managed by voluntary organizations and a few of these can be visited by the public. Of these, the most visually impressive are the large turreted Wignacourt structures and the one erected at Mellieħa in Lascaris' time. The largest and most complex of these is the Santa Maria Tower on the island of Comino, which was built in 1618. It contains various unique features which set it distinctly apart from its sister structures: a wide masonry plinth which allowed it to acquire a greater height; its base (on top of the plinth) was enveloped by an all-round musketry gallery for close-in-defence (this feature is no longer standing); and the whole structure was enveloped within a countermined glacis. This tower still proudly bears a marble escutcheon with Grand Master Wignacourt's coat-of-arms.

Also open to the public is St Paul's Bay Tower, the first built and smallest of all Wignacourt's towers. The Knights' records reveal that the foundation stone ceremony was held on 10 February 1610 in the presence of the Grand Master and the clergy of the Mdina Cathedral, following a procession and solemn mass at the nearby church of St. Paul. Today the tower contains a small museum dedicated to the Knights' fortifications. Built in the same year as St Paul's Tower, is St Lucian Tower in Marsaxlokk harbour. Nowadays, it can be seen enclosed within an impressive outer coastal fort (Fort St. Lucian), built to house three heavy riffled muzzle-loading guns in casemated emplacements by the British military in the late nineteenth century. The proposal for its construction was first presented on 1 July 1610 and work was embarked upon with great

St Agatha's Tower, also known as the Red Tower, is not strictly coastal, but provided a vital line of communication with the smaller coastal watchtowers of Northern Malta.

enthusiasm such that the tower was practically completed in around eleven months. On 11 June 1611, the Grand Master, accompanied by many knights, sailed on board the Galera Capitana to examine the finished edifice and to witness its arming with bronze cannon and munitions. Nowadays, Fort St Lucian serves as the seat of the Malta Aquaculture Research Centre.

No less impressive is St Thomas Tower in Marsaskala. This was built immediately after the devastating Ottoman razzia of 1614: the last serious invasion of the Maltese islands. Structurally, it differs from the other Wignacourt towers in the treatment of its corner turrets which are more pronounced and project outwards to form veritable small pentagonal bastions, giving the structure the distinctive shape of a four-bastioned fort.

Of the smaller watchtowers, the best preserved are those found at Ħamrija, Triq il-Wiesgħa Tower (known as Torre del Migiales or Torre Giddida), Qalet Marku, Għallis, L-Aħrax tal-Mellieħa, St. Julians, Wied-iż-Żurrieq (Ta' Xutu), Lippija, and Madliena. Madliena Tower is the only one which the British military sought to convert into a Martello-type tower, with a roof-mounted gun on a traversing carriage. The four coastal towers in Gozo – at Dwejra, Xlendi, Nadur and Mġarr ix-Xini – have also undergone restoration over recent years. Of these, the Dwejra Tower, which was completed in 1652 and financed by the Università of Gozo, is open regularly to visitors.

Salt Pans[3]

Ritienne Gauci

Introduction

“Salt is born of the purest parents: the sun and the sea,” Pythagoras (495 BC) once said, capturing the simplicity of salt’s natural creation. Yet, for centuries on the Maltese Islands, salt has been nurtured by two additional parents: the coast and the people. Salt pans, carved out of limestone shores, harnessed the sun and sea, producing salt through an enduring tradition.

The salt pans on the Maltese coast, also referred to as salinas, bear witness to the cultural and environmental heritage present on the archipelago and which have been an integral part of the local economy and identity for centuries. It is among the first ‘products of excellence’ that Malta began producing at a proto-industrial level from the 17th century onward.

This chapter explores the geoheritage value of Maltese salt pans by examining their unique geographical and geological setting, the physical evolution of low sloping coasts and shore platforms that crafted the ideal space for salt panning, and, the traditional artisanal methods of salt harvesting. Special attention will be devoted to three locations where salt production remains active. Despite the pressures of modernity and the intense competition from imported salt, a small number of salt workers remain steadfast, embracing their millenary artisanal craft along the coast. Salt pans contribute to Malta’s cultural legacy, while continuing to attract visitors who seek to experience an enduring fusion of geoheritage and traditional craftsmanship.

Geography of Maltese salt pans

The interplay between the Mediterranean climate, islands' geomorphology and limestone geology has shaped an ideal coastal landscape for salt production on the Maltese Islands. Malta's climate is highly favourable for salt production, with hot, dry summers that accelerate the evaporation process and mild, wet winters that provide periodic rains.

The Maltese coastline stretches for 272 km, with rocky coasts comprising 90.5% of its length. The coastal landscape is largely shaped by tectonic activity and exposed geological layers, resulting in an uplifted fault block and a north-eastern tilt of about 4°. This structure creates distinct coastal features: the southern and south-western coasts are marked by steep, plunging cliffs, while the northern coastlines slope gradually to form low cliffs and gently sloping rocky shores. On the island of Gozo, an easterly dip gives rise to high cliffs on the western coast and gently sloping shorelines along the northeastern and eastern coastlines.

This unique geomorphological setting, combined with the limestone geology of Globigerina Limestone, have shaped the low-sloping rocky coasts and sub-horizontal shore platforms along the northern and north-eastern coasts of the islands. These formations are the most prevalent coastal landforms, covering nearly 37% of Malta's coastline. However, not all salt pans were hewn out of Globigerina Limestone. Those at Blata tal-Melħ (Baħrija) were hewn on Lower Coralline Limestone, the densest and hardest of all rock formations on the Islands.

Shore platforms are gently sloping rock surfaces (0°-5°) that formed from horizontal or slightly inclined geological outcrops at sea level. Shaped by marine processes, such as wave erosion and weathering actions, these platforms are typically backed by retreating soft cliffs and terminate in abrupt low cliff lines with deeply carved notches at mean sea level. On the Maltese Islands, shore platforms can be found between 5 and 10 metres above sea level and are seldom submerged due to Malta's microtidal conditions. They developed around 6,000 years ago when sea levels reached their present height.

As a result of natural salt weathering processes and wave erosion, these platforms often manifest a honeycomb-like surface with naturally occurring shallow pools with flat bottoms. The presence of these pools encouraged the creation of the earliest forms of human-made pans, as these natural pools were widened and enlarged for salt production. These rocky shore platforms provided the foundation for Malta's distinctive salt landscapes, where human interventions built upon and extended natural processes to produce salt.

Not all salt pans were born out of small natural pools, however. Industrial efforts in the 20th century, supported by state financial aid, led to the creation of extensive salt pans in areas such as Xrobb l-Għaġin in Malta, Ir-Reqqa Point and Għar il-Qamħ in Gozo. The latter two projects were abandoned, leaving permanent scars on the coast as reminders of unrealized ambitions.

Salt pans are concentrated along the coastal areas of Malta and Gozo where shore platforms, sloping coasts and salt marshes lie at low elevations above sea level. Active sites which are still in operation today - such as in Xwejni Bay in Gozo, Salina Bay, and Delimara Point - illustrate such a geographical disposition, as they are located on accessible rocky or sheltered embayed coasts that allowed for the natural accumulation and evaporation of seawater to produce salt. Their strategic location, close to both natural bays and inlets, and the earliest towns and villages, made these coastal zones ideal for the labour-intensive process of artisanal salt harvesting.

Historical development

The distinct physical geography and climate, combined with Malta's limited natural resources, have historically positioned salt as a valuable local commodity, essential for food preservation and other practical uses such as skin tanning. The origins of Maltese salt pans date back to at least the medieval period, though it is likely that small-scale salt extraction from naturally forming rock pools occurred even earlier. The local manufacture of salt became a royal monopoly under the Norman rule (1194–1530), reflecting its value as a commodity for local consumption as well as for trade and revenue generation.

Later, during the rule of the Knights of St. John (1530–1798), salt production was actively managed and expanded as a strategic resource. Historical documents illustrate how the place name *Mellieħa* (semitic word for 'salt pan') sprang around the island during this period, such as '*Mellieħa taż-Żonqor*' (1509), '*Mellieħa ta' Bengħisa*' (1557) and *Mellieħa ta' Ras il-Ħobż* (1746). Maps also offer tantalizing hints of a former 'salty' identity for tourist bays like Għadira Bay. In Antonio Francesco Lucini's 1631 map, the bay is labelled *Porto delle Saline Vecchie* (Port of the Old Salt Pans), while its hinterland, the saline marshland of Għadira Bay, is described as a *pianura*, suggesting it was once a salt flat.

And if Għadira Bay had 'old' salt pans, where were the 'new' ones located? To ensure a steady supply, the Knights established large salt pans at Salina Bay, near the mouth of the Burmarrad ria valley. This site was developed into a state-funded *salina*, with extensive basins and a system for seawater collection and evaporation, allowing the Knights to control production and distribution. They imposed a monopoly, fixed prices, and enforced penalties for unauthorized salt production, ensuring that salt remained an important and profitable resource. The local population began to engage in artisanal salt harvesting along the coasts, often under strict regulatory oversight by the ruling authorities.

During the 18th century, Malta managed to feature in the European salt trade routes. Production was an all-time high on the Salina salt pans, reaching around three million kilos of salt per year. The 19th century saw continued growth in salt production during British rule, with significant improvements to infrastructure that facilitated larger yields. In 1867, for example, Malta's *salinas* produced around four million kilos of coarse salt annually, with the bulk exported. However, as industrialisation transformed global salt production, Malta's traditional methods faced economic challenges. With increased mechanisation and the expansion of industrial-scale saltworks elsewhere, Malta's smaller-scale operations struggled to compete, and many salt pans fell into disuse.

By the mid-20th century, demand for artisanal salt had declined considerably due to the growth of imported, mass-produced salt. Many traditional salt pans were abandoned or repurposed. Others, such as those at Salina Bay have secured European Union funds and have been restored into a Salina family park, with a dedicated interpretation centre about salt harvesting. A resurgence of interest in local, artisanal products in recent decades has breathed new life into Malta's salt pans. Today, the few remaining active salt pans, such as those in Xwejni Bay on Gozo and Delimara Point on Malta, are primarily operated by families who have passed down salt-harvesting techniques through generations. These families maintain the traditional methods and seasonal rhythm of salt production.

The process of salt harvesting

The process of salt harvesting from Maltese salt pans is a carefully orchestrated practice, involving multiple stages of evaporation and collection. It starts from the month of July, when the limestone is sufficiently warmed during the longer days of summer, and the weather is dry and stable. This artisanal process, which has remained largely unchanged for centuries, showcases the dedication and skill of local salt workers who are intimately connected to their saltscapes. The steps in the traditional salt-making process are generally as follows:

a. Pan preparation: The pan bottom is allowed to form a protective duricrust by the weathering process and by the salt itself, in order to be fully functional. Edges of pans may also require repair following any storm-derived damages during the winter months.

b. Reservoir collection: In early summer, seawater starts being pumped into a series of large reservoirs, strategically positioned near the shoreline or on elevated parts of the platform, to facilitate seawater by gravity flow to the smaller pans. These large reservoirs serve as the main source of cold sea water that is then distributed to another set of smaller and shallower reservoirs known as warming pans.

c. Brine generation in warming pans – These smaller reservoirs are found in all sizes, shapes and depths. Though shallower depths facilitate rapid warming, these reservoirs have to occupy a volume seven times the surface area of the crystallizer pans they are meant to supply. Eight days of warm, dry weather turns the seawater of these reservoirs into hypersaline brine.

d. Evaporation and crystallisation: The hypersaline brine is transferred by gravity channels from the warming pans to a sequence of smaller shallower basins that will serve to crystallise the salt, hence referred in this work as crystallizers. This controlled environment facilitates fractional crystallization, where calcium salts precipitate first, followed by sodium chloride (common salt) in the final basins. Once the hypersaline brine reaches a critical concentration, salt crystals begin to form.

e. Salt collection: At this point, the salt is manually harvested from the shallow pans by scraping it into small piles to drain and dry. This labour-intensive process is carried out with soft brushes and spades to ensure that the salt remains pure. The harvested salt is then collected into larger piles, where it undergoes further drying before being transported to store for further drying and final packaging for sale.

This artisanal method, passed down through generations, requires skill and patience, as salt workers must monitor the evaporation process closely to ensure optimal conditions for salt crystallisation. The knowledge associated with managing salt pans is largely experiential, acquired through years of practice and adaptation to changing environmental conditions.

Xwejni Salt Pans, Gozo

Located along the rugged northern coastof Gozo, the Xwejni salt pans near Marsalforn stretch across some two kilometres, forming one of islands' most picturesque and historically significant salina sites. Managed by the Cini family for over a century, the Xwejni salt pans are arranged in a network of evaporation basins and crystallizers meticulously carved out of the Lower Globigerina Limestone covered in lower phosphatic conglomerate bed (Figure 1). The hard conglomerate allowed the expansion of a sub-horizontal shore platform backed by Middle Globigerina Limestone cliffs.

At Xwejni, salt harvesting is a family affair, with generations passing down traditional techniques and knowledge. Emanuel Cini of Xwejni, the current salt worker, described the earliest works done on the natural pools by people who crossed over from Sicily. Salt used to be harvested from these pools and traded to other ports in the Mediterranean. The delicate nature of the limestone requires regular maintenance, especially after winter storms, which often erode parts of the salt pans. Mr Cini, and his enterprising daughter Josephine, use both traditional and modern methods to manage the salt pans, including pumps to raise seawater into the basins and manual tools to clear debris and maintain the pan structure.

Most of the large warming pans are denoted by Maltese names to distinguish them from others. For example, they have named the basins mostly for their physical characteristics, such as *Il-Baxx* (meaning the shallow one), *Tas-Salib* (meaning the one with the cross), *It-Twil* (meaning the long one), or *Tal-Kantun* (meaning the one with a slab of rock).

The Xwejni salt pans have become a popular destination for tourists, students and locals, where visitors can observe or participate in the salt-harvesting process.

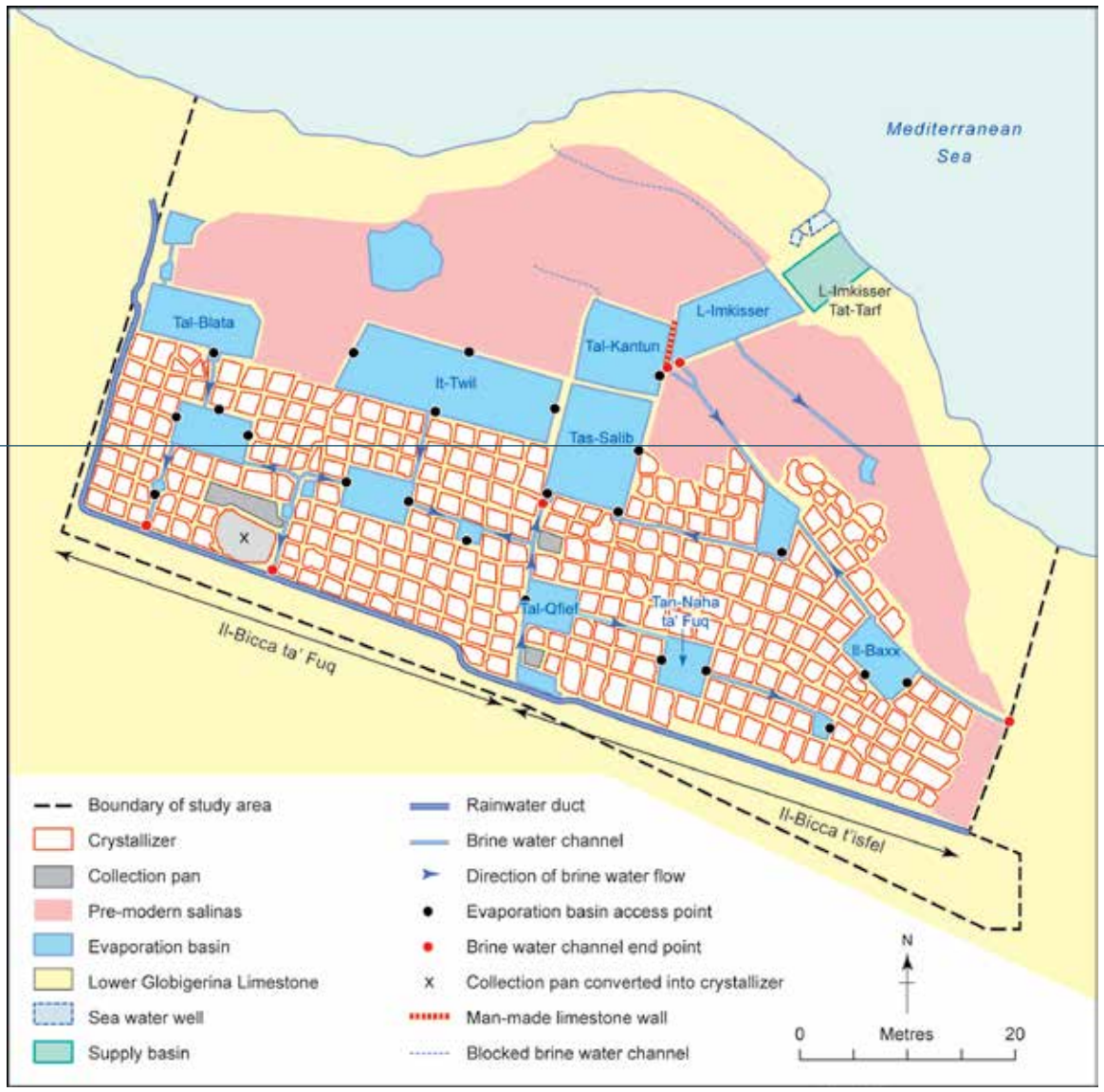


Figure 1: Spatial representation of the traditional salt harvesting system managed by the Ċini family at Xwejni Bay, Gozo. Evaporation basins are referred as warming pans in the text. (Source: Gauci et al. 2017, licenced for reproduction under Creative Commons Attribution 3.0 License).

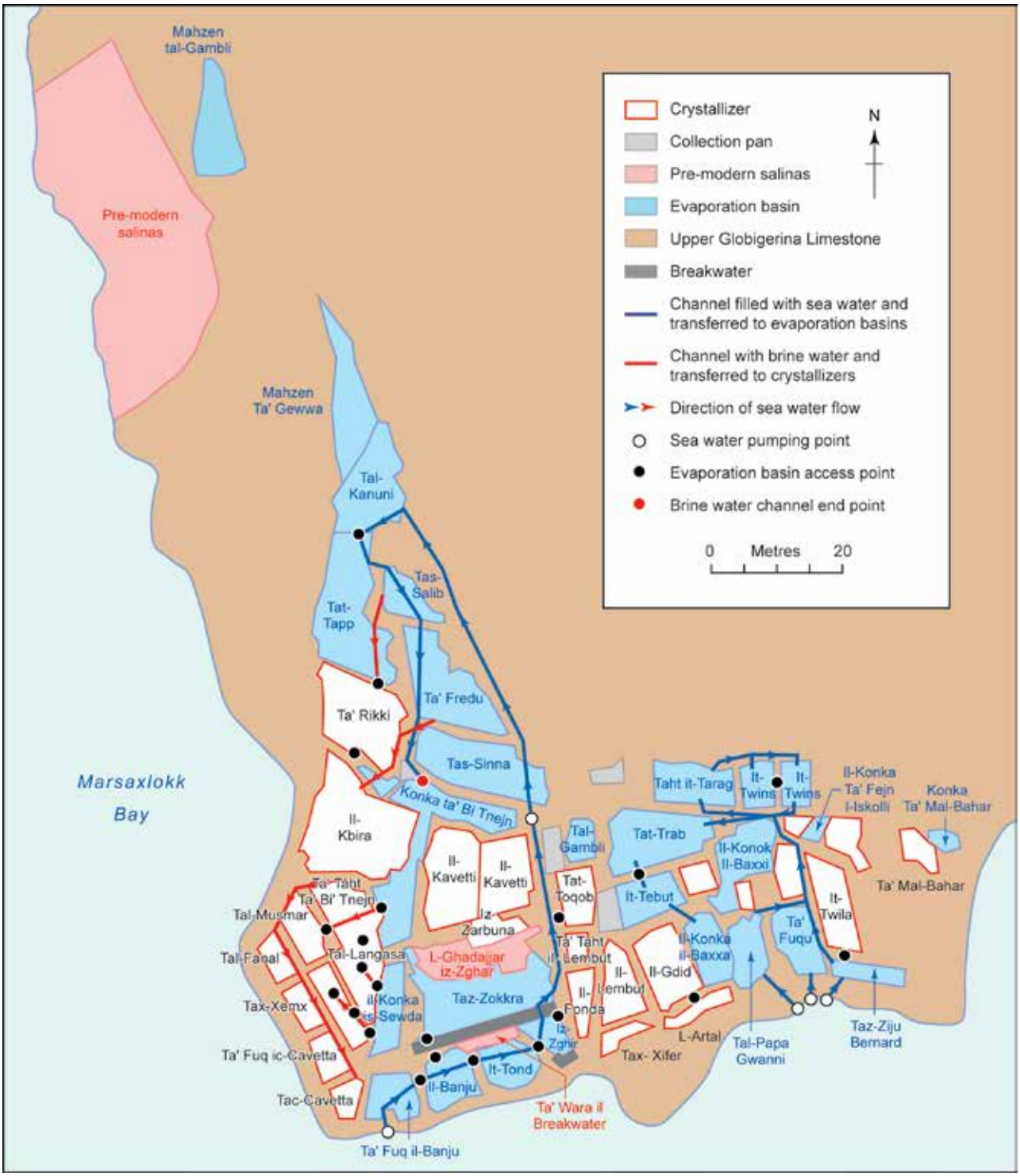


Figure 2: Spatial representation of the traditional salt harvesting system managed by the Mangion family at Delimara, Malta. Evaporation basins are referred as warming pans in the text.
(Source: Gauci et al. 2017, licenced for reproduction under Creative Commons Attribution 3.0 License).

Delimara Salt Pans, Malta

On Malta's south-eastern coast, the Delimara Peninsula hosts another prominent site for salt production. The Delimara salt pans, managed by the Mangion family, are located on the Delimara Point shore platform, a sub-horizontal limestone surface gently sloping towards the sea (Figure 2). The area is geologically unique, with visible tectonic faults creating slightly uneven terrain that influences the arrangement and layout of the salt pans. The Delimara salt pans are carved into the Upper Globigerina Limestone, which is well-suited to forming shallow pools for salt crystallization due to its low resistance to erosion.

The salt pans lie at the base of a high cliff, accessible only by long ladders set against the cliff face. Over the years, salt worker Charles Mangion expanded the natural pools using hand tools, creating the intricate network visible today. In favourable weather, salt harvesting can occur weekly. Salt deposits are divided into equal squares, and piles of salt are shovelled toward the centre of each square. After draining and drying, the salt is winched up the cliff to reach street level.

Similar to Xwejni, the Delimara salt pans represent more than just nameless rocky saltscapes. Salt pans possess a unique identity, deeply connected with the site-specific features and the people who tend them. Their site features are endowed with names which hold personal memories and familial histories. A number of warming pans are related to their shape or location, for example, It-Twins (meaning, the twins) is the name of two warming pans that are identical in shape and are located next to each other. Tal-Langasa (meaning, of the pear) salt pan owes its name to its pear-shaped form while Iż-Żarbuna (meaning, the shoe) is a salt pan that resembles the shape of a shoe. Il-Lembut refers to its shape as a funnel, whereas Tax-Xifer (meaning, the one at the edge) refers to its position at the edge of the platform.

The Salina Salt Pans, Malta

Salina represents the largest system of salt pans on the archipelago, featuring the most extensive network of irrigation channels and embankments, covering a total area of 99,160 m². It includes ten crystallizers, each approximately 1,600 m² in size. Additionally, the site contains twelve evaporation basins, one semi-warm water reservoir, and one cold-water reservoir. Though it is now part of the Natura 2000 network, the Salina merits consideration for future nomination as a World Heritage Site.

The salt pans are located within a valley delta and a ria harbour, with archaeological evidence indicating that this harbour was a bustling commercial centre during Roman times. Historical maps of the 1565 Great Siege, drawn by Antonio Francesco Lucini and Mattia Perez D'Aleccio, suggest that salt pans already existed in the Burmarrad valley, but they were hewn higher up along the rocky coast rather than within the harbour waters. The current salt pan system at Salina Bay was not carved into land but built on a reclaimed island within the enclosed port, connected to the mainland by bridges.

Over the years, the Salina has undergone several modifications, including a reduction in size when the coastal road was constructed in the mid-20th century. A 1900 survey shows that Pans 1-9 were used as crystallizers (Figure 3). Converting Pan 10 from an evaporation basin to a crystallizer proved challenging, as seawater from the 23 evaporation basins struggled to meet the volume needed to replenish the large crystallizers, which require nine times their volume in water. This large-scale production at Salina sets it apart from all other artisanal salt pans on the islands. Conservation measures were initiated in 1996 when the Malta Environment and Planning Authority (MEPA) included the Salina salt pans and its environs in the list of scheduled property and declared it as Special Area of Conservation (SAC).

Salt production begins in March with the cleaning and scrubbing of the salt pans. The cold-water and semi-warm water reservoirs are successively filled and left to settle, allowing impurities to separate from the seawater. Warmer water is then directed by gravity to warming pans, and once sufficiently heated, it flows into the crystallizers. There, it gradually crystallizes into salt over several weeks. During this process, the seawater turns pink and thickens, eventually forming floating salt crystals that accumulate in larger deposits (Figure 3). Before harvesting, excess water is drained, and the salt cover is chiselled into uniform squares to facilitate stacking into salt pyramids. The nearby Ximenes Redoubt serves as the final collection and storage point for these dried salts.

The Salina salt pans were rescued from deterioration and partial submersion by the European Agricultural Regional Development Fund (EAFRD). Over the years, they had been left to silt over and to become waterlogged. Retaining walls, embankments, and walkways had to be rebuilt, and silt and clay were cleared from the pan bottoms. The old, heavily deteriorated storage huts were replaced with state-of-the-art wooden sheds, designed to store salt and serve as an interpretation centre.

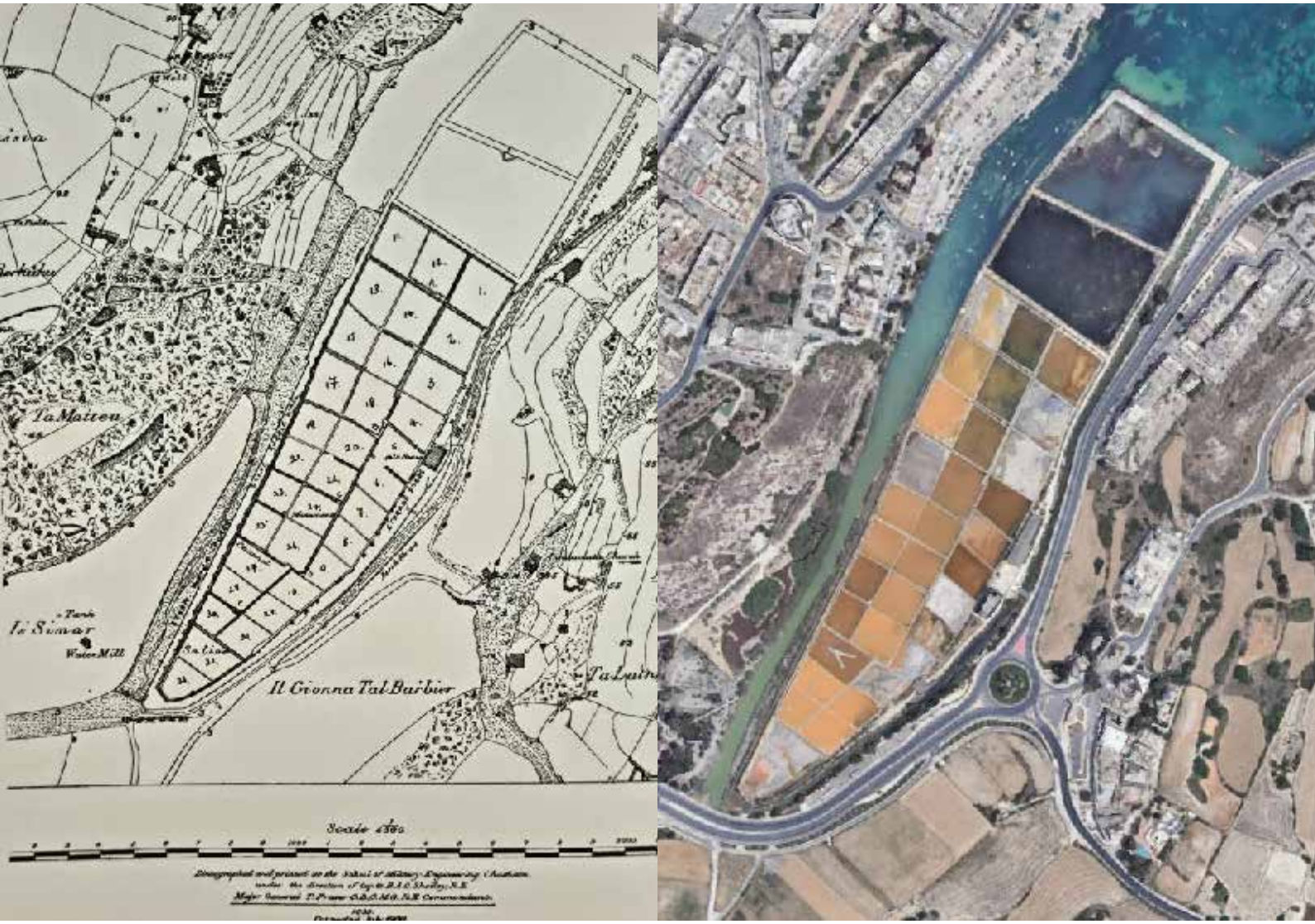


Figure 3: Site map 1:2500, dated 1900, with the numbering system for each pan (left); Google Earth image of the Salina Bay (right), showing the coloured hues of the saline water in pans during evaporation process. (Source of 1900 map [left] Clarke E.V. and Agius-Vadala M., 1995; Satellite imagery [right] extracted by author, Map data ©2024 Google).

A labour intensive industry: salt panning at Xwejni, limits of Marsalforn, northern Gozo.

Salt pans are worth one's salt as geoheritage

Today, local salt is marketed as a niche, high-quality, gourmet product, often valued for its purity and unique mineral profile, which reflects the Maltese coastal environment. The traditional salt pans are also promoted as part of Malta's geo-cultural heritage, drawing tourists who are keen to observe or participate in salt harvesting. Geo-tourism initiatives, such as guided visits to the salt pans, offer hands-on experiences and a connection to Malta's heritage.

Thus, the salt pans of the Maltese Islands represent more than a means of salt production. While they no longer serve the island's economy, they endure as symbols of its history, culture, and craftsmanship, showcasing a sustainable and artisanal tradition that continues (albeit barely) to enrich our coastal landscape. They embody a heritage that reflects the ingenuity and resilience of the people of these Islands. Their presence on Malta's limestone coasts highlights a symbiotic relationship between natural geology and human craft, where generations of salt workers have shaped, and been shaped by, the coastal landscape.

Preserving this geoheritage requires an understanding of both the physical environment and the traditional knowledge that sustains it. However, this system relies on the skilled, long-term knowledge of local artisans to function effectively. The expertise required to manage the salt pans is rooted in continuous interaction with the coast and the gradual adaptation of traditional methods to evolving environmental conditions. This tacit knowledge, passed down through the hands-on experience of past generations, is essential to preserving Malta's artisanal salt-making practices.

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Godfrey Baldacchino BA(Gen), PGCE, MA (The Hague), PhD (Warwick) is a professor with the Department of Sociology at the University of Malta, and Malta's first Ambassador-at-Large for Islands and Small States (2021-2024). He is curating a volume (with photographer Daniel Cilia) exploring the various islands, islets and rocks of the Maltese archipelago. He served as President of the International Small Islands Studies Association (2014-2022).

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Keith Buhagiar BA(Hons), PGCE, MA, PhD specializes in rural landscape formation and development, related water management systems and Maltese and Sicilian medieval and Early Modern cave-settlements and rock-excavated oratories. Dr Buhagiar lectures in Paleochristian, Byzantine and Medieval archaeology at the University of Malta.

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Stephen C. Spiteri Dipl. (Int. Des.) RI, BA(Hons), PhD, is a military historian, author, lecturer and preservationist. His work mainly deals with the military history of Malta, particularly military architecture, and is a recognized expert on Malta's fortifications. He is the Research Coordinator of the Restoration Directorate, the Maltese government's entity responsible for restoring historic buildings. He is also a lecturer at the International Institute for Baroque Studies of the University of Malta.

Notes

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