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## Proposal for the nomination of Lower Globigerina Limestone of the Maltese Islands as a “Global Heritage Stone Resource”

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(Received: June 21, 2016; Revised accepted: November 29, 2016)

<http://dx.doi.org/10.18814/epiiugs/2017/v40i3/017025>

*The Lower Globigerina Limestone of the Maltese Islands is here being proposed for nomination as a “Global Heritage Stone Resource”. This stone, continuously used for building and sculpture for 6000 years, is well suited to fit this global designation as it is not only of great local cultural, historic and economic importance, but it is also the building stone used in construction of the UNESCO, and hence internationally recognized, World Heritage city of Valletta, as well as the UNESCO-listed Prehistoric Megalithic Temples of the Maltese Islands. The stone was also exported to several European and North African countries especially in the early 20<sup>th</sup> century. The entire range of archaeological remains and historic architecture which cover the Maltese Islands have been built in this stone, and encompass innumerable palaces and churches, including the fortified cities of Valletta, Mdina (the old capital of Malta), the Three Cities on the Grand Harbour and the Citadel of Gozo, as well as the vernacular architecture ubiquitous within the village cores all over the Islands. The soft limestone has also been widely used over the millennia for elaborate and extensive sculptural motifs. Practically the only natural resource of the Islands, it continues to be quarried today, and is used not only for new construction, but also for the regular restoration of Malta’s great and imposing architectural heritage, remaining thus an important pillar of the Maltese economy.*

### Introduction

This paper is aimed at proposing Lower Globigerina Limestone, extracted in the Maltese Islands, for nomination as a “Global Heritage Stone Resource” (GHSR). This stone has also been called “Malta stone” in the past, and is currently referred to, in the construction industry, as “franka” (meaning “freestone”), or “softstone”. The stone will be defined according to its geological setting and characteristics, historical and cultural importance over the millennia, as well as its significance as an economic resource, which it continues to be today.

These will cover the nomination criteria that have been established by the Board of Management of the Heritage Stone Task Group (HSTG), as specified in the Task Group’s checklist for “Global Heritage Stone Resource” designation (revised October 2014), and as reported on the Global Heritage Stone website [www.globalheritagestone.com](http://www.globalheritagestone.com).

### Criteria for GHSR Recognition

Criteria for designating a Global Heritage Stone Resource (GHSR) have been developed by the Heritage Stone Task Group (HSTG) of IUGS and Commission C-10 of IAEG (Cooper, 2014). The Heritage Stone Task Group checklist states that a natural stone can be recognised as a GHSR if most of the following attributes are covered:

- historic use for a significant period (at least 50 years);
- wide-ranging geographic application;
- utilisation in significant public or industrial projects;
- common recognition as a cultural icon;
- ongoing quarrying and availability; and
- providing potential benefits (cultural, scientific, environmental and/or commercial) (Marker, 2014).

Thus, for a stone to be nominated it must have been widely used over a long period of time, needs to have acquired cultural and historical significance by being used in significant buildings or sculpture, and be still quarried. The case will be made here that, for the Lower Globigerina Limestone of the Maltese Islands, all of these criteria are fulfilled. In the case of wide geographical use, which is also a desirable criterion, this is not an essential GHSR characteristic (Hughes et al., 2013). The paper will nonetheless discuss how international recognition of the stone has been achieved, by having significant buildings in Malta recognised as UNESCO World Heritage, including the entire capital city of Valletta, wholly built of this limestone, as well as what are classified as amongst the oldest free-standing structures in the world, the Maltese Prehistoric Temples (<http://whc.unesco.org/en/statesparties/MT/>). In addition, this stone is still being extracted from a number of quarries in the Maltese Islands, and, in being one of the very few mineral resources on the Islands, is a significant asset to the local economy.

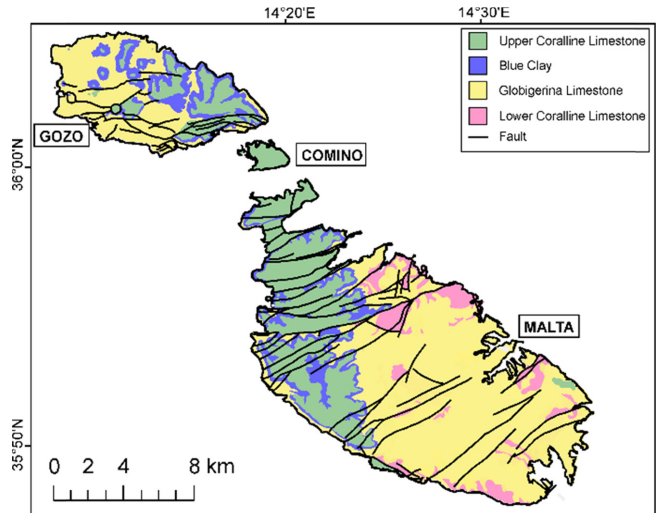
It is on the basis of these criteria, which will be further discussed

below, that the Lower Globigerina Limestone is being proposed for nomination as a GHSR by a working group (authors) within the University of Malta, where research on the stone has been conducted for the last 30 years; this research covers geochemical, mineralogical and petrographical studies, as well as the determination of physical and mechanical properties (Bianchi, 1975; Cachia, 1985; Bonello, 1988; Zammit, 1989; Saliba, 1990; Farrugia, 1991; Sammut, 1991; Xuereb, 1991; Cassar, 2002, 2004, 2010; Cassar and Vella, 2003; Rothert et al., 2007; Cassar et al., 2008; Diana et al., 2014; Zammit and Cassar, 2017) – data given in Table 1 (below). This paper will also be utilised as the main vehicle to provide the data as required by the Checklist for “Global Heritage Stone Resource” Designation (revised October 2014).

**The Stone and Its Context**

The Maltese Islands consist of three main islands (Fig. 1), covering approximately 316 km<sup>2</sup> of exposed land, lying 93 km due south of the Ragusa Peninsula of Sicily on the southern end of the Pelagian shelf. The Islands are made up of sedimentary rocks, ranging from pure carbonates to marly-carbonates, formed in marine water depths of up to 200 m on a stable near-horizontal platform (Pedley et al., 1976). The Maltese sedimentary sequence consists of five formations – (from oldest to youngest) Lower Coralline Limestone, Globigerina Limestone, Blue Clay, Greensand, Upper Coralline Limestone (Fig. 2) – covering the Oligocene (Paleogene period) and Miocene epochs (Neogene period) (Pedley, 1978). The outcropping succession also includes sporadic Quaternary deposits.

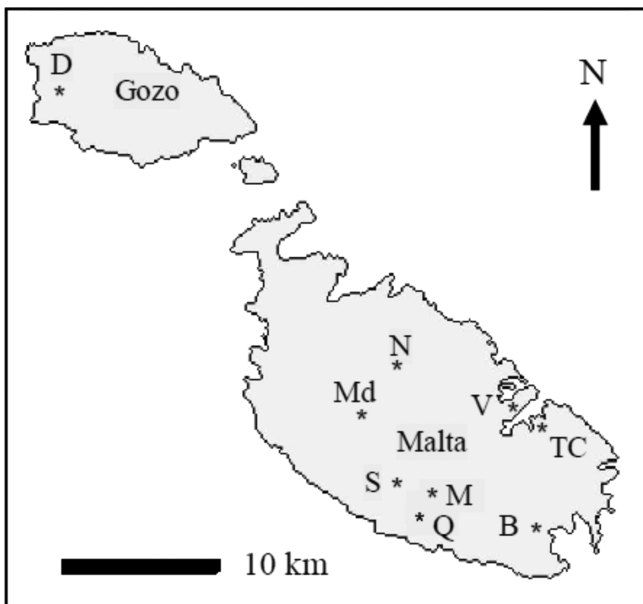
The Globigerina Limestone Formation forms part of the Oligo-Miocene ‘soft limestones’ found widely in the Mediterranean Basin, including Turkey, Israel, Tunisia, Spain and Italy. It is the most widely distributed formation on the Maltese Islands, and consists of a yellow to greyish, medium to fine grained wackestone-packstone dominated



*Figure 2. Geological map of the Maltese Islands, showing the five main sedimentary formations, including the Globigerina Limestone Formation, which is the source of the stone being proposed for nomination as a GHSR (Source: Oil Exploration Directorate, 1993).*

by planktonic foraminiferid tests (Baldassini and Di Stefano, 2017). The formation is massive, poorly to moderately consolidated, and intensely burrowed. The Globigerina Limestone Formation was deposited in outer shelf environments between the Late Chattian and Langhian, and is up to 200 m thick (Pedley et al., 1976).

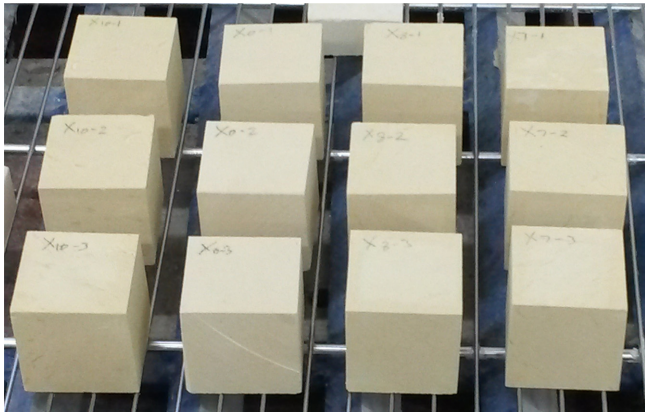
The Globigerina Limestone Formation is made up of three members, called the Lower Globigerina Limestone, Middle Globigerina Limestone and Upper Globigerina Limestone, separated from each other by two phosphatic hardgrounds (named C1 and C2) (Pedley et al., 1976). It is Lower Globigerina Limestone, the oldest member of the Globigerina Limestone Formation, which has been used as the main local building material for millennia (Fig. 3). The thickness of the Lower Globigerina Limestone member varies from > 100 m in the Valletta Basin, to < 5 m along western Malta (Pedley et al., 1976). Lower Globigerina Limestone (Fig. 4) comprises planktonic foraminiferal biomicrites, biomicrosparites, wackestones and packstones



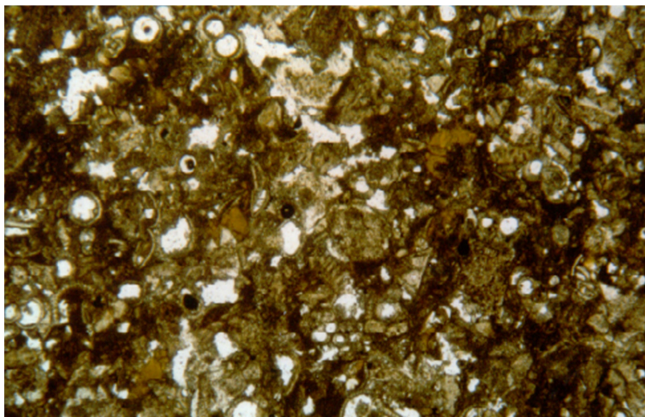
*Figure 1. Map of the Maltese Islands showing main urban and quarry areas. Key: D = Dwejra (San Lawrenz), N = Naxxar, Md = Mdina, S = Siggiewi, M = Mqabba, Q = Qrendi, B = Birzebbuga, V = Valletta, TC = Three Cities (Cottonera).*



*Figure 3. Open pit quarry extraction in the quarry area of Mqabba, Malta. Extraction is by automated sawing machines. Processing starts in the quarry and continues on site.*



**Figure 4.** Close surface view of sawn cubes of *Globigerina* Limestone, showing fine, smooth and homogeneous texture, but some colour variations. The size of each cube is  $5 \times 5 \times 5$  cm.



**Figure 5.** Optical microphotograph of *Globigerina* Limestone showing fine texture, foraminifera, micritic matrix and inter- and intra-granular porosity. Crossed nicols,  $\times 2.5$ .

dominated by globigerinid tests (Fig. 5), which are pale yellow, massively bedded and medium to fine grained (Pedley et al., 1976; Baldassini and Di Stefano, 2017). Most of the original bedding of the member has been destroyed by intense bioturbation. This is particularly the case in the deeper section of the Lower *Globigerina* Limestone member, where anomalously dense and large bioturbation gives rise to the “soll” layer – a very fine cream to yellow bedded limestone that weathers rapidly and unevenly. Lower *Globigerina* Limestone is comprised of calcite (> 92%) as well as small amounts of quartz, feldspar, apatite, glauconite and clay minerals. Detailed composition data have been published in Cassar (2004). The total porosity is very high, reaching values of up to 41.4% (Cassar and Vannucci, 2001). Further geotechnical and petrophysical data on the Lower *Globigerina* Limestone are provided in Table 1 below. Macrofossils within this member include echinoids, molluscs and pteropods. Lower *Globigerina* Limestone is weathered via solution and salt weathering, primarily through granular disintegration, scaling and alveolar weathering. The Lower *Globigerina* Limestone member is interpreted to have been deposited in water depths over 200 m in a depositional environment characterized by free access to the open sea, aerobic conditions, and moderate sedimentation rates (Murray, 1890).

Quarry workers have long recognised the varying aesthetic and weathering characteristics of the Lower *Globigerina* Limestone. Depending on the quarry area from where the stone is extracted (especially whether it is from the island of Malta or the sister island of Gozo) and depth of extraction (Sammut, 1991), stone “types” have been given different names, associated primarily with appearance but also with some notable changes in physical properties. These include “bajda” (white), “bajda tal-wicc” (surface white), “bajda bit-tebgha tas-sadida” (white with rust stains), “safra” (yellow), “kahla” or “sewda” (blue or black), as well as varying types of “soll” ranging from “soll ahmar” (red “soll”) to “soll isfar” (yellow “soll”) to “soll ikhal” (blue “soll”). In Malta, the nomenclature is primarily related to typology, whereas in Gozo the nomenclature is strictly sequential. “Gebra tal-franka” (“gebla” meaning “stone”) is, however, the generic name for this building stone. Whereas many of the types of “franka” stone are generally reputed to weather well, stone obtained from the various types within the “soll” facies is alleged to be less durable and will deteriorate in a few years, depending on exposure. The two extreme ends of this scale of variations of Lower *Globigerina* Limestone have been found to differ in geochemical and mineralogical composition, and also in physical properties (Cassar and Vella, 2003; Zammit and Cassar, 2017). The causes of deterioration have been recognised to be the intrinsic properties of the material, as well as environmental causes, including temperature changes, wind, sun, humidity, pollution and the presence of soluble salts (Cassar, 2002).

## History of the Use of the Stone

The Maltese Islands can be characterized both by their strategic location in the central Mediterranean, which has dictated their history of occupation since the Neolithic Era, and their sedimentary geology. The succession of colonisers, who took over the Islands particularly because of their central position, always made good and full use of the readily available and easily quarried soft limestone to build their palaces, temples, forts, as well as magnificent walled cities surrounded by kilometres of fortifications. This activity occurred against a slowly developing backdrop of vernacular building activity which included houses and churches, many of these richly adorned with marvelous and intricate carved decorations. The “franka” or “softstone”, is by far the predominant local building and sculptural material, although Coralline Limestone, or “hardstone”, another locally occurring stone, has also been widely used on these Islands, but has been somewhat less exploited. The most significant use of the *Globigerina* Limestone has been on the Maltese Islands, with UNESCO recognising the entire capital city of Valletta, as well as the megalithic prehistoric Temples as World Heritage, mainly built of this limestone; however, over past decades, the stone has also been exported, in not insignificant amounts, to countries such as Italy, Greece and Libya (Mamo, 1936; Ellul, 2010). Ellul (2010) gives a total of about 126,000 tons exported between 1909 and 1938.

The Maltese Islands have been inhabited for more than six thousand years, with every generation of inhabitants going through more or less intensive periods of building, starting with the prehistoric period which has left behind a rich legacy of magnificent and well-preserved megalithic monuments, built between the 4<sup>th</sup> and the 3<sup>rd</sup>



**Table 1. Description, composition, properties, supply and use of Lower Globigerina Limestone**

Formal Name	Lower Globigerina Limestone
Stratigraphic (or Geological) Name	Lower Globigerina Limestone
Commercial Designations	“Franka” “Softstone”
Other Names	“Malta stone”
Area of Occurrence	Central and southern part of the Island of Malta and northwest of the Island of Gozo (Fig. 2)
Principal Location of Extraction Sites	Mqabba/Qrendi/Kirkop (active quarries); Siggiewi (active quarries); Naxxar and Birzebbugia (abandoned quarries) – all on the Island of Malta; San Lawrenz (active quarries) on the Island of Gozo In 2013, 66 quarry licenses were processed; there are also a number of sites that are no longer operating or where operations have been suspended (Fig. 1).
Production Details (optional)	Recent research based upon aerial photography taken in 1994 and 1998 estimated an annual production of 400,000 m <sup>3</sup> of “softstone” (Entec, 2003). There is, however, a lack of a nationally agreed database on production.
Manufacturing information	The processing of the stone starts in the quarry itself and continues on the building site. It is entirely local. There have been some technological advances in the extraction of this stone over the last decades, but it remains a basic industry. In the past, the stone was entirely extracted by hand. Nowadays, extraction is made using semi-automated sawing machines. Other quarry equipment includes facing machines, conveyors and lorries. The blocks are cut to specific sizes, established by law, and delivered directly to the construction site, where they may be further finished or carved. (Entec, 2003)
Geological Age and Geological Setting	Sedimentary rock deposited in water depths over 200 m in an environment characterized by free access to the open sea, aerobic conditions, and moderate sedimentation rates (Pedley et al., 1976). Aquitanian (Early Miocene, 23.03–20.44 Ma) in age (Felix, 1973; Pedley et al., 1976); Oil Exploration Directorate (1993); (Foresi et al., 2007; Baldassini et al., 2013)
Petrographic Name and Characteristics	Globigerinid biomicrites, biomicrosparites, wackestones and packstones, pale yellow to cream in colour, medium to fine grained, massive, bioturbated limestone characterized by a uniform texture (Pedley et al., 1976; Baldassini and Di Stefano, 2017).
Primary Colour(s) and Aesthetics of Stone	Pale yellow to cream in colour; usually homogeneous; iron oxide stains and bioturbation often occur. Colour determination by Munsell soil colour charts have given the following ranges: 10YR 6/3, 10YR 8/2, 10YR 7/6, 2.5Y 7/4, 2.5Y 8/4, 2.5Y 8/2
Technical Properties	Real density: 2628–2800 kg/m <sup>3</sup> Apparent density: 1630–1851 kg/m <sup>3</sup> Compressive strength (uni-axial): oven-dry 15.0–37.84 N/mm <sup>2</sup> Compressive strength (uni-axial): saturated 7.95–16.3 N/mm <sup>2</sup> Tri-axial compressive strength, confining stress: 1 N/mm <sup>2</sup> : 24.6 N/mm <sup>2</sup> Tri-axial compressive strength, confining stress: 5 N/mm <sup>2</sup> : 31.6–38.6 N/mm <sup>2</sup> Tri-axial compressive strength, confining stress: 10 N/mm <sup>2</sup> : 35.1–38.6 N/mm <sup>2</sup> Flexural strength (oven dry): 1.1–4.7 N/mm <sup>2</sup> Flexural strength (saturated): 1.2–3.7 N/mm <sup>2</sup> Point load strength index: 0.4–1.4 N/mm <sup>2</sup> Shear strength, unconfined: 2.2–3.85 N/mm <sup>2</sup> Modulus of elasticity, static: 20–22 kN/mm <sup>2</sup> Modulus of elasticity, dynamic: 22–25 kN/mm <sup>2</sup> Poisson’s ratio: 0.22 Chemical analysis (average) CaO: 49.71%; SiO <sub>2</sub> : 4%; Al <sub>2</sub> O <sub>3</sub> : 1.18%; MgO: 0.71%; Fe <sub>2</sub> O <sub>3</sub> : 0.66%; below 0.5%: P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O, TiO <sub>2</sub> , Na <sub>2</sub> O, MnO Mineralogical analysis (average) Calcite (up to 99%), Quartz (up to 8%), Feldspars (up to 1%), Clay minerals (up to 12%) Porosity: 23.9–40.7% Average pore radii: 0.56–1.06 μm Pore surface: 3.4–12.8 m <sup>2</sup> ·g <sup>-1</sup> Water uptake rate (atm. pressure): 14.1–20.8 wt% Capillary water uptake w value: 3.1–9.6 kg·m <sup>-2</sup> ·h <sup>-1/2</sup> Saturation coefficient: 0.66–0.95 Water vapour diffusion resistance: 7.78–7.83 (μ value) Hygic expansion: 0.20–0.25 mm m <sup>-1</sup> Thermal dilatation coefficient: 2.32–4.51 K <sup>-1</sup> USPV parallel to bedding plane: 2.61–3.00 km s <sup>-1</sup> USPV perpendicular to bedding plane: 2.68–3.15 km s <sup>-1</sup> (Cachia, 1985; Bonello, 1988; Saliba, 1990; Sammut, 1991; Xuereb, 1991; Farrugia, 1993; Tampone et al., 1994; Cassar and Vella, 2003; Cassar, 2004; Rothert et al., 2007; Cassar et al., 2008; Diana et al., 2014; Zammit and Cassar, 2017).
Suitability	Widely used as a structural material, for building houses, churches (with vaults and domes), public buildings, palaces, schools, hospitals, universities, etc. Also widely used for sculpturing from free-standing objects of all sizes, to intricately carved in situ stonework. Also flagstones, corbels, roofing slabs, and ornamental work. Used since the Neolithic period.
Vulnerability and Maintenance of Supply	In 1994, the first ever “Mineral Resource Assessment” was carried out for the Maltese Islands. A final draft report was submitted to the Planning Authority in June 1996. Suitable mineral resources were proven in a number of target areas, and for “softstone”, the reserves were estimated at 429 million tonnes (or about 430 years production) (Entec, 2003).

Table 1. (continued)

Historic Use, Geographic Area of Utilisation, Commercial Diffusion	Time span: 4 <sup>th</sup> millennium BC to present – 6000 years of continuous use. Geography: all over the Maltese Islands; exported in the past to areas such as North African countries (including Libya, Tunisia and Egypt), Greece, including Crete and Corfu, and Turkey, as well as mainland Europe (Belgium, France, Holland, Italy) and the UK. In all of these cases the amount exported was small, and limited to a few years, except for export to Greece, Italy and Libya. (Ellul, 2010) Historical use: Prehistory, Phoenician, Roman and Byzantine, Arab, Late Medieval, Baroque, 19 <sup>th</sup> century, Modern
Buildings etc.	All of the Maltese Islands' main public institutions are built of the Globigerina Limestone: <ul style="list-style-type: none"> <li>• the Presidential Palace (façade begun 1571)</li> <li>• the Offices of the Prime Minister (Auberge de Castille – 1741–44)</li> <li>• Ministerial Offices (the Auberges of the Knights – late 16<sup>th</sup> century)</li> <li>• the main hospitals in Malta and Gozo (20<sup>th</sup> and 21<sup>st</sup> centuries)</li> <li>• the Law Courts (1965–1971)</li> <li>• the current University of Malta and the old University (1960s; 1592–1609)</li> <li>• historic theatres (1731, 1860)</li> <li>• the Bibliotheca and public libraries and archives and schools (late 18<sup>th</sup> century; 20<sup>th</sup> century)</li> <li>• kilometres of fortifications, forts and watchtowers (16<sup>th</sup>–17<sup>th</sup> century)</li> <li>• all monasteries, main cathedrals and churches, as well as smaller chapels including rural ones (Medieval to 20<sup>th</sup> century)</li> <li>• National museums (16<sup>th</sup>–19<sup>th</sup> century)</li> <li>• and vernacular architecture (Medieval to 21<sup>st</sup> century)</li> </ul>
Related Heritage Issues	Cultural relevance: Prehistoric Temples, and city of Valletta, Malta's capital city are UNESCO World Heritage sites. Others, such as the walled city of Mdina, the Cittadella (Gozo), and the Knights' Grand Harbour area fortifications have been formally submitted, and are currently on the UNESCO Tentative List. ( <a href="http://whc.unesco.org/en/statesparties/MT/">http://whc.unesco.org/en/statesparties/MT/</a> )
Related Dimension Stones	Coralline Limestone
Principal Literature related to the Designated Stone	See list of References



**Figure 6.** The Prehistoric Temples of Malta (4<sup>th</sup>–3<sup>rd</sup> millennium BC), included on the UNESCO World Heritage List, are amongst the earliest free-standing stone structures in the world. Hagar Qim, shown in this figure, as well as the Temples of Mnajdra and Tarxien, are now sheltered for their conservation.

millennium BC (Fig. 6). These are considered to be amongst the oldest freestanding buildings in the world, and are inscribed on the UNESCO World Heritage List as some of the earliest still extant limestone structures in the world, listed “because of their originality, complexity and striking massive proportions, but also because of the considerable technical skill required in their construction” (<http://whc.unesco.org/en/list/132>). Other remains from later periods, scattered all over the Islands, include Bronze Age defended settlements, Phoenician sanctuaries and rock-cut tombs, Roman villas, estates and baths in the countryside and by the sea, late Roman and Byzantine Catacombs, and Islamic burial grounds. All are built with this local material, important to the present day (<http://www.culturalheritage.gov.mt/>).

The first recorded mention of the limestone of the Maltese Islands



**Figures 7 (upper) and 8 (lower).** The fortifications of the cities of Mdina (late 17<sup>th</sup> to early 18<sup>th</sup> century) and Valletta (late 16<sup>th</sup> century) (shown here), and those of Vittoriosa and the Citadel (Gozo) (not shown here) comprise over 60 km of massively built Globigerina Limestone bastions, enceintes, ramparts and watch towers.





**Figures 9 (upper) and (lower) 10. Two of the most prominent buildings in the UNESCO city of Valletta, Auberge de Castille (the current Offices of the Prime Minister) (1741–44) and the Co-Cathedral of St. John, the Conventual Church of the Knights (1573–77). Other prominent buildings in the City include the Presidential Palace (formerly the palace of the Grand Master of the Knights of St John) (began in 1571) and the Bibliotheca (National Library) (1786–96) which houses the archives of the Order of St. John.**

was in *The Earliest Description of Malta* published in Lyons in 1536 by Jean Quintin d’Autin (Vella, 1980, pp. 37–39) who mentions the “white” stone which is “remarkable for its softness; it is sawed more easily than wood.” The mode of excavation is also mentioned: “Often huge blocks of stones are prised loose by wedges from the solid rock. Hence it is worked easily...” Another *Descrittione di Malta*, this time dating to 1716, mentions that the houses are made of white stone, which is very easy to cut (Mallia-Milanes, 1988, p. 51).

But by far the greatest and best use of the stone prior to modern



**Figure 11. One of the decorative portals of the old capital of Mdina, the Main Gate (1724).**

times was made during the Renaissance and Baroque periods, under the Knights of St John. These include numerous systems of fortifications (over 60 kilometres in length) which, following extensive recent restoration efforts, still glorify the Maltese urban landscape (Figs. 7 and 8). Malta’s rich Renaissance and Baroque architectural heritage extends beyond the UNESCO recognised capital city, Valletta ([whc.unesco.org/en/list/131](http://whc.unesco.org/en/list/131)), built by the Knights after the Great Siege of 1565 (Figs. 9 and 10). The fortified city of Mdina (Fig. 11), the old capital of Malta, still stands as proud testimony to the great 18<sup>th</sup> century architect François de Mondion, who was the resident engineer of the Knights of St John from 1715 to 1733 (Mahoney, 1996, p 208). Other imposing constructions in this stone include the fortified Three Cities of the Grand Harbour area, as well as numerous villages spread all over the Maltese archipelago, characterized by magnificent and elaborate Baroque churches (Fig. 12) that dominate the Maltese skyline (<http://www.culturalheritage.gov.mt/>). Vernacular architecture in this honey-coloured stone also characterizes the Maltese landscape (Fig. 13).

In 1800, when the Maltese Islands passed under British Colonial Rule, architectural styles and building techniques changed slowly; however the main construction material remained the local Lower Globigerina Limestone. When construction did take place, especially in the early period, it was primarily in the form of military buildings, and monuments to naval and army officers; residential barracks and forts and fortifications were also built (Spiteri, 1991). The preferred





**Figure 12.** The elaborate façade of one of Malta's most prestigious limestone Baroque Churches: the Church of St. Caterina d'Italia (Valletta) (1713).



**Figure 14.** The 19<sup>th</sup> century Neo-Gothic church at the Addolorata Cemetery, Malta.



**Figure 13.** Typical and traditional village streetscape, with traditional limestone houses and decorative stone balconies.

style for British constructions was the Neo-Classic Revival “to assert their presence on the Islands and as a symbol of their Imperial might

and glory” (Mahoney, 1996, p. 211). Local architects, such as the renowned Emanuele Luigi Galizia also left his mark during this period (Fig. 14).

At the beginning of the twentieth century, new aesthetic ideas were introduced, with the Romanesque, the Neo-Gothic, and the Art Nouveau movements being the main ones. In the last two decades, more innovative, hybrid styles were introduced, influenced by an increased appreciation of the Islands' architectural heritage and current trends in Europe (<http://www.victorborg.com/>). All continued to make extensive use of the local limestone.

The soft Maltese limestone has also been extensively used for sculpture, from very simple forms to elaborate representations, even from prehistoric times. The megalithic Temples bear elaborate spiral carvings (Fig. 15), as well as animal reliefs and stone statues and statuettes. The Romans used the stone to carve busts and heads, as well as

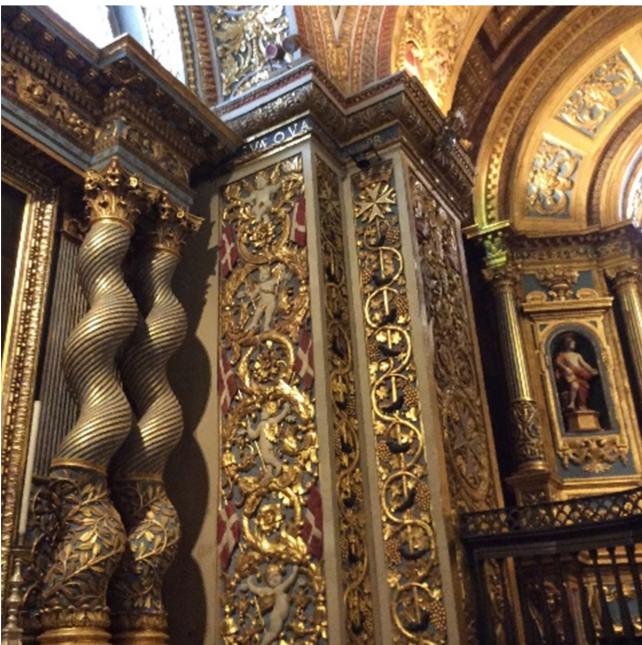


**Figure 15.** Prehistoric limestone relief, dating to the Neolithic, carved out of the soft limestone with stone (obsidian and chert) tools.





*Figure 16. The easily carved Lower Globigerina Limestone effortlessly lent itself to elaborate and profuse Baroque sculpture. An extravagant doorway in the old city of Rabat (Malta).*



*Figure 17. The magnificent carved and gilt interior (all of carved Globigerina Limestone) of St. John's Co-Cathedral in Valletta, the Conventual Church of the Knights of St. John. Many of the Baroque buildings built by the Knights had correspondingly meticulously carved interiors.*

great fluted columns and capitals to decorate their buildings. However, the pinnacle of stone carving in Malta was achieved during the Baroque Period (Fig. 16), as exemplified by the inside of St John's Co-Cathedral in Valletta (1577), when extremely elaborate decorations were carved, with the same ease as carving wood (Fig. 17).

## The Stone as an Economic Resource

There are currently around 100 licensed "softstone" and "hardstone"

quarries in Malta and Gozo (Fig. 3). In 2013, the Malta Resource Authority processed 34 new licenses to operate "softstone" quarries, and 32 renewals (MRA, 2013). The "softstone" industry is operated by a work force of approximately 500 persons (Lino Bianco and Associates, 2000), mostly part-timers or family members. The gross annual production for this stone has been given to be in the region of 860,000 m<sup>3</sup>. It has, however, also been estimated that 45% of "lesser quality" quarried material is discarded annually. The reserves of "softstone" and "hardstone" in existing local quarries, or where quarrying is permitted have been arguably estimated to last fewer than 40 years (Times of Malta, 2003).

There is, however, a lack of a nationally agreed database on production, with data output generally being incomplete. Research based upon aerial photography taken in 1994 and 1998 estimated an annual production of 400,000 m<sup>3</sup> of "softstone" (Entec, 2003). Data on the amount of quarry stone which is used annually for the maintenance and restoration of historic buildings is not available; however it is important to note that it is also the continued use of this stone in new buildings that keeps the quarries active and a relevant part of the local economy.

In 1994, the first ever "Mineral Resource Assessment" was carried out for the Maltese Islands. A final draft report was submitted to the Planning Authority in June 1996. Suitable mineral resources were proven in a number of target areas, many not currently quarried, and for "softstone", the reserves were estimated at 429 million tonnes (or about 430 years production at the current rate of extraction) (Entec, 2003).

In construction, the whiter resources, with a consistent colouring, tend to be preferred by consumers. Minor variations in colour can result in the stone being discarded. Decisions on material quality are still made at the quarry face, on the basis of visual assessment, with significant resulting wastage (Entec, 2003). Today, "softstone" quarrying is going through a lull, with the stone becoming less popular for everyday constructions, and with much fewer quarries being active, also as a result of the decline of both the manpower as well as the skills required for stone masonry. The present active ones are primarily located in two areas in Malta (Mqabba and Siggiewi), and in one area in Gozo (Dwejra) (Fig. 1).

## GHSR Nomination/Citation Requirements

Following the 2014 checklist, outlining the data required in order to nominate a natural stone as a GHSR, Table 1 gives the information requested.

## Conclusion

The Globigerina Limestone Formation is described as a yellow to greyish, medium to fine grained wackestone-packstone which is massive, poorly to moderately consolidated, and intensely burrowed. Deposited in outer shelf environments between the Late Chattian and Langhian, it is up to 200 m thick. It is made up of three members, of which it is the Lower Globigerina Limestone which has been used as the main local building material in continuous use for 6000 years. It



comprises planktonic foraminiferal biomicrites, biomicroparites, wackestones and packstones dominated by globigerinid tests. Most of the original bedding of the member has been destroyed by intense bioturbation.

All buildings and sites of importance in the Maltese Islands are built using this stone, including those designated as UNESCO World Heritage sites. There has also been a degree of exportation of the material in the past, with buildings such as the Royal Palace in Athens, St Louis Cathedral in Carthage and a Protestant Church in Naples being built of this stone. The cultural and historical significance of this limestone is thus indisputable. Although the durability of this material is variable, and some facies are known to deteriorate badly in the marine environment in which they are located, other strata are of exceptional durability, with hundreds, or even thousands of years not having a deleterious effect on the materials. Quarrying continues to the present, the stone being the only natural resource of any importance to be found on the Islands. The material is still an important pillar of the Maltese economy. A Resource Assessment (in 1994) estimated that the Globigerina Limestone resources can last another 450 years. This however would involve opening up new areas, something which is not currently being considered. The permitted reserves of “softstone” and “hardstone” in existing local quarries are however estimated to last about 40 years.

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