THE FIRST 55 IUGS HERITAGE STONES

International Union of Geological Sciences

GEOHERITAGE IUGS INTERNATIONAL COMMISSION ON GEOHERITAGE

Messages

It is a pleasure to introduce this volume of the First 55 IUGS Heritage Stones. These have been chosen by peer-review and represent only part of the collection of heritage stones that will be recognised by the International Union of Geological Sciences (IUGS) over the coming years. The teams involved in these selections not only study the petrography, geological setting, and the geographic occurrence, but also the architectural and cultural impact of the stone. Indeed, some of the stones are essential in building economic value others have enormous artistic value – of note might be the Carrara Marble used by Renaissance artists. The specimens span six continents and multiple millennia in their use.

This book is one that you pick up from time to time from a convenient table, while sipping a beverage and discover the importance of stones in our civilisation. Some localities will immediately be evident as they may also be important in national heritage, others might be more obtuse as to why they are included, but they will be equally fascinating.

If you are not a geologist, I expect you will be bemused by the names we give to rocks. These are mainly based on the localities from which the type specimens were described and can be quite poetic; the Jaisalmer Golden Limestone or the Turkish Denizli Travertine, migmatites and charnockites and many more!

I thank all of those involved in developing the IUGS Heritage Stones volume.

Please enjoy the read.

Professor John Ludden CBE

President of the International Union of Geological Sciences (IUGS)

Stone carvings and artworks of the Paleolithic are among the earliest expressions of human creativity and ritual. The emergence of sophisticated stone shelters during the Neolithic marked significant technological and cultural advancements, reflecting humans' evolving relationship with their environment and growing architectural skills. The use of stone with favorable characteristics in architecture and art followed the growth and evolution of societies and cultures. These special stones are an essential part of our heritage and show the important role of geological sciences along human history. Many cities and iconic monuments across the world are strongly influenced by a specific stone. Geologists have long appreciated these heritage stones not only for their qualities, but also for their geological meaning. The IUGS Subcommission on Heritage Stones aims to give recognition to those stones that are linked to the evolution of human culture. The first 55 are here presented for the appreciation of those who take interest in the history and nature of human stone use.

Stan Finney
Secretary General
of the International Union
of Geological Sciences (IUGS)

Asier Hilario
Chair of the International Commission
on Geoheritage of the IUGS
Basque Coast UNESCO Global Geopark

About the Heritage Stone Subcommission (HSS)

The International Commission on Geoheritage (ICG) of the International Union of Geological Sciences identifies, recognises, and designates significant geological heritage sites, stones, and collections (https://iugs-geoheritage.org/). The International Commission on Geoheritage (ICG), established in 2016 during the 35th International Geological Congress held in Cape Town, South Africa, has grown significantly and now includes three dedicated subcommissions: the Subcommission on Geosites, the Subcommission on Heritage Stones, and the Subcommission on GeoCollections. These subcommissions operate under revised uniform terms of reference as of 2022.

The initiative "Global Heritage Stone Resource", along with IAEG Commission C-10 on Building Stones and Ornamental Rocks, established the framework for the Heritage Stone Subcommission during the 33rd International Geological Congress in Oslo, Norway in 2008. This project was elevated to an IUGS-Heritage Stone Task Group for a four-year period during the 34th IGC in Brisbane, Australia in 2012. Finally, at the 35th IGC in Cape Town, South Africa, in 2016, the Heritage Stone Subcommission was officially founded as part of the ICG. In the year 2020, the rejuvenated International Commission on Geoheritage consolidated the programme of designation of 'IUGS Heritage Stone' by identifying, recognizing and designating natural stones that have played significant roles in major architectural works worldwide, reflecting cultural heritage. The IUGS Heritage Stone designation aims to promote the geological knowledge, usage, and conservation of these culturally, architecturally, and historically significant natural stones. It also serves as an excellent outreach activity, raising public awareness about geological heritage and encouraging its protection and celebration (https://iugs-geoheritage.org/).

The designation process involves meeting specific criteria, giving the recognized stones a distinct identity and value on an international level. The criteria for recognizing heritage stones include significant cultural relevance based on historical and archaeological use, reflecting its importance in cultural evolution, and use in the past. It also involves consideration of traditional and indigenous beliefs and cultural practices related to the stone. Stone built heritage sites must be iconic monuments synonymous with cultural identity. A description of stone's location and geology is mandatory which includes its geological age, petrographic name, stratigraphic name, comprehensive petrographic and technical description. Documentation of known active and historical quarries, along with information on the ongoing availability of material for quarrying, including historical quarries that are no longer active but preserved also form part of the criteria for the designation of 'IUGS Heritage Stone'.

Documenting Heritage Stones holds significant societal relevance, including the preservation of local traditions and the enhancement of the area's cultural and social heritage. Scientifically, it offers valuable benefits through research and knowledge that can aid restorers and architects in using the same Heritage Stone for building restoration. The most important outcome is increasing awareness and highlighting the importance of geological heritage among the population. This book outlines fifty-five stones from various parts of the world which have been designated as 'IUGS Heritage Stone'.

Gurmeet Kaur

Chair of the ICG Subcommission on Heritage Stones

THE FIRST 55 IUGS HERITAGE STONES

Introduction

JoAnn Cassar
(L-Università ta' Malta)

In this first-of-a-kind book, "The First 55 IUGS Heritage Stones", we celebrate building stones, decorative stones and stones used for statuary, which embody human ingenuity and skill and are testimony to cultures and societies, which have appeared - and disappeared - over time. Stone has the ability to merge the tangible with the intangible and thus bears testimony to rituals, traditions, religion, ceremonies and human resilience, as well as past technologies, manual skills and even interconnectivity across space and time. Recognition that the stone which surrounds us can be extracted, cut, carved and shaped has been here since the dawn of time, with the first such activities directly linked to day-to-day survival: to provide food and shelter. The very first stone tools were used by Homo Erectus and then passed on to Homo Sapiens, perhaps 2 million years ago. Later, in the Palaeolithic, a desire to embellish the immediate surroundings emerged, represented by the extraordinarily life-like first cave drawings in limestone caves (e.g. Lascaux and Altamira). During the Neolithic, more defined and refined stone weapons and implements, figurines, and also simple jewellery emerged, and temples and other buildings started appearing; available clay resources were exploited to make sun-dried brick and, later, fired brick and pottery. Practical use of available geological resources grew.

As greater and lesser civilizations flourished, the use of these materials developed and became practically ubiquitous - reflecting their availability and workability, and the skill and resourcefulness of the people who learned how to manipulate them. Taking a journey around the world, we find that in the prehistoric Mediterranean, the Neolithic peoples of Malta built their complex Megalithic Temples in limestone, and in Sardenia, nuraghi, dolmen and menhir were erected in granite. However, even in these distant times, stones were also being transported over great distances - take Egypt where, together with the use of local limestone, granite was also used, transported over long distances from Aswan to the Giza plateau to be used mostly for facing; and in Great Britain bluestone was transported from Wales for use in Stonehenge, together with the local stone. Other examples from around the world include the monolithic churches of Lalibela, Ethiopia, carved out of the surrounding volcanic scoria (ignimbrite), and the Longmen Grottoes, in China, with their impressive limestone statues, representing the high point of Chinese stone carving. Fast-forward to the Greco-Roman world, expressions of power and might are embedded in stone temples and

statuary, created in white (but often painted) Parian Marble (Greece) whilst also finding the Romans extracting and transporting coloured marbles all around the Mediterranean and beyond.

Early use of stone in the Americas found the Olmecs, Mayans, the Incas and Aztec Empires constructing superb buildings, including pyramids, in the local stones (limestone, sandstone, granite, volcanic tuff). Who has not heard of, and possibly also visited, Machu Picchu in Peru (granite) and Teotihuacan in Mexico (using the local Tezontle)? But even in this region, "poorer" materials were also used when readily available, one example being the magnificent Chan Chan (Peru) built of earthen materials.

Reflecting the abundant, readily available and easy to use earthen materials, there was widespread and resourceful use of sun-dried and later also fired brick in Asia. Cultures which used such materials included the Harappan culture in the Indus Valley (e.g. Mohenjo-daro, in modern day Pakistan), and the Sumerian and Babylonian Kingdoms in Mesopotamia. Here too, over time, great and elaborate use of stone developed - take Angor Wat in Cambodia (laterite and sandstone), Borobudur in Java (andesite and basalt), and Kailasanathar Temple in India (sandstone and granite).

These are the stones this book celebrates: magmatic (granites, basalts, tuffs, and other), metamorphic (marble, gneiss, slate, charnockite), and sedimentary (limestones, sandstones, breccias, laterite).

This richly illustrated and informative book thus explores, over time and geographies, the art and architecture carved out of stone, and is a tribute to the creativity of the human mind, the awe-inspiring manual skills and an eternal wish to not only grace the present, but also the future, in the perennial "durable" material which we are celebrating: Heritage Stone. From the quarrying of available materials - be they limestone, marble, granite, gneiss or slate - selected for aesthetic considerations and/or intrinsic properties, to the transport, cutting, carving and finishing of these timeless materials, we today can only marvel at how the great stone monuments of the world were created, and the materials used. Thus, we find that it is information on the stones themselves that allows us to have a complete understanding of these artistic and architectural marvels. This information is however usually not readily available, and it is this great lacuna that this book seeks to address.

We have thus prepared a book - an opus - which presents to the reader a close interaction between the original location of the stone (geological setting, quarries), what the stone is (petrography, mineralogy) and the diverse uses of the material over the millennia (heritage issues, social and cultural impact). The examples come from Asia, Africa, Europe, the Americas and Australia. From Europe we have examples in the porous and easily carved Globigerina Limestone of Malta, a stone used for UNESCO recognised sites such as the capital city of Valletta; the iconic green Connemara Marble from Ireland, used expertly in buildings such as the Museum Building of Trinity College in Dublin; Lede Stone from Belgium, a sandy limestone used in several UNESCO listed buildings in Belgium and France; Villamayor Stone, used on the façades of splendid monuments of Salamanca (a World Heritage City); Bath Stone, used in the graceful Georgian Buildings of Bath (also listed by UNESCO) and the iconic Portland Stone used in St Paul's Cathedral in London; the black Podpeč Limestone from Slovenia, used in internationally important Slovenian buildings: Parliament, City Hall, National Library and University Library; and Virolahti Pyterlite from Finland, used extensively for

the construction of the city of St Petersburg in Russia. From the Americas, a stone of great local importance is the sandstone Piedra Mar Del Plata from Argentina, which produced a unique architectural style symbolic of the middle class; and Tennessee "Marble", a limestone from North America that has been quarried continuously since colonial times and has great importance in the United States and Canada. Canada itself showcases Tyndall Stone, a dolomitic limestone from Manitoba, used in numerous important buildings in Canada, the USA and even Germany; while Tezoantla White Tuff of Mexico was the stone of choice for notable Baroque and Neoclassical monuments in the historic centre of Mexico City. Brazil showcases Facoidal Gneiss as the most representative natural stone of the city of Rio de Janeiro; India boasts Jaisalmer Limestone, used to build the Jaisalmer Fort (a UNESCO World Heritage Site) and one of Rajasthan's most magnificent forts, and also employed for intricate carvings and monuments; Makrana Marble is the stone of the Taj Mahal. Australia celebrates Malmsbury Bluestone, a basalt which was used widely throughout Oceania.

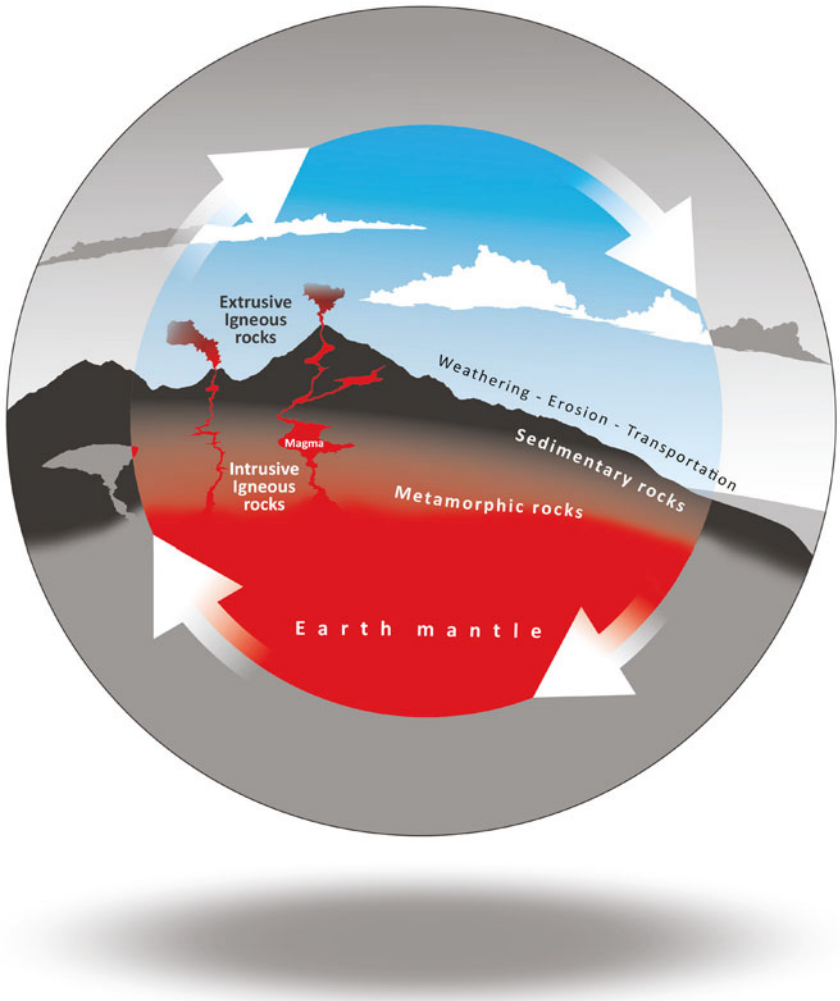
Other stones presented here have had a wider reach and influence. Carrara Marble from Italy was used by Renaissance artists to carve sculptures which still grace the cities of Rome and Florence and has been exported all over the world. Afyon Marble from Türkiye has also spread since Roman times to shores as distant as South Spain and South England. Solnhofen Limestone from Germany is not only known as a building stone but also the world's most famous lithographic stone. Welsh Slate has been used since Roman times and has been exported all around the world. We illustrate also other slates: Valentia Slate (Ireland), German Roofing Slate and Himachal Slate (India). From Norway, Larvikite is one of the world's most popular ornamental stones, a symbol of fashion and wealth used on prestigious façades in London and Paris.

Many other stones appear in this informative compendium of IUGS Heritage Stones. From Europe we present Belgian Black Marble and Petit Granit (Belgian Bluestone), French Échaillon Stone, German Rochlitz Porphyry Tuff and Jura Limestone, Italian Pietra Serena, Rosa Beta Granite and Sardinian Basalt, Norwegian Iddefjord Granite, Portuguese Lioz and Ançã Limestones, Portland Stone (UK), Radkow Sandstone (Poland), Brecha da Arrábida, Estremoz Marble and Porto Granite (Portugal), Spanish Alpedrete Granite, Bernardos Phyllite, Lugo Green Phyllite, Red Ereño Limestone and White Macael Marble, Swedish Hallandia Gneiss and Kolmården Serpentine Marble. From a country straddling both Europe and Asia, we have Denizil Travertine (Türkiye). From Mexico we present Tezontle Scoria, Asia is graced with Indian Alwar Quartzite, Deccan Basalt, Charnockite and Western Ghats Laterite, as well as Tsukuba Massif Granite from Japan. Africa makes an appearance with the Lalibela Basaltic Scoria (Ethiopia) and the United States presents us with Jacobsville Sandstone.

Having admired this carousel of beautiful and meaningful Heritage Stones, we will arrive at the end of our journey. We have greatly enjoyed preparing this richly illustrated overview of a representative sample of our Heritage Stones, spanning four continents and many millennia, highlighting their sources, composition and properties, iconic buildings, statuary and decorations, created locally and elsewhere. It is hoped that this book will give the reader equal pleasure.

We all look forward to the next Heritage Stones to be nominated and designated.

The Rock Cycle and the three rock types



The **Rock Cycle** refers to a dynamic scheme whereby the three major types of rocks, igneous, sedimentary and metamorphic, are all linked. Taking a cross section through the Earth's crust, the igneous rocks are formed at depth or are extruded at the surface from volcanoes. All the surface rocks are subjected to mechanical and chemical breakdown, and their products are transported by water or wind and deposited, often in layers, and later lithified into sedimentary rocks. As burial depth of these rocks increases, so too do pressure and temperature and they may can be converted into metamorphic rocks at depth. Increased heating can ultimately result in the melting of rocks and the formation of magmas that become igneous rocks, and the rock cycle continues.

Metamorphic rocks are produced when a rock is subjected to heat and or pressure and undergoes transformation. The nature and type of the resultant metamorphic rock depends on the composition of the original rock, or protolith, and the degree of heat and pressure applied.
This alteration can be generated at a large regional scale through tectonic collision or locally where a hot igneous rock comes into contact with an adjacent older country rock.
The greater the change, the higher the metamorphic grade. Limestone gets transformed into marble, mudrocks into slates or schists, and granites, at a high grade, into gneiss.

BERNARDOS PHYLLITE

Spain

El escorial

Phyllite roofs from the Spanish Baroque

A legacy quarrying since the late 16th century

Victor Cardenes

The extraction of Bernardos Phyllite dates back to the late 16th century, initiated by the directive of King Philip II. His mandate aimed at locating slate deposits in the vicinity of Madrid to supply the necessary material for the development and construction of new imperial structures.

For centuries, the Bernardos Phyllite was synonymous with nobility and excellence, with an important representation on the Spanish Stone and Architectural Heritage.

Today, these quarries continue to yield phyllite, serving the needs of both contemporary architectural projects and restoration endeavors. Notably, Bernardos Phyllite faces no significant heritage concerns, with its only challenge being the competition posed by foreign rocks of lesser quality.

Bernardos Phyllite (20 x 30 cm)

Petrography

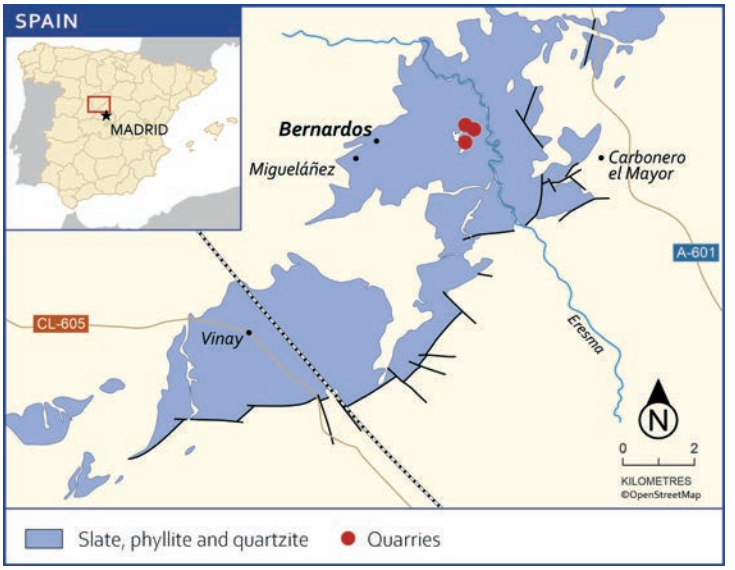
Bernardos Phyllite displays the characteristic texture for a fine-grained phyllite. There is a strong structural control due to the intense and penetrative slaty cleavage.
Texture is porphyro-lepidoblastic, with grains of quartz and chlorite deformed by the slaty cleavage, developing cinematic structures such as pressure shadows.
The matrix is composed mainly by mica. Accessory minerals are biotite, rutile and some iron sulphides and carbonates. Texture and mineral composition is that typical for roofing slates.

Petrography
Phyllite

Geological setting
Precambrian- Lower Cambrian;
Massif of Santa María La Real, (Iberian Massif)

Occurrence
Bernados, Province of Segovia, Spain

Location and geology



The Massif of Santa María La Real, (Iberian Massif) is an outcrop of Precambrian - Lower Cambrian materials, affected by the Hercynian Orogeny and surrounded by the Tertiary basin of eastern Spain. This structure is the result of the compression stresses that occurred during the Alpine Orogeny. From a petrological standpoint, there are two units: the Ollo de Sapo Gneiss and the Schist-Greywacke Complex.

The Schist-Greywacke Complex (SGC) is a series of pelitic and carbonate sediments of different grain sizes affected by metamorphism.

Productive outcrops are located in the upper part of this unit, where the phyllitic levels reach up to 30 metres thickness and the slaty cleavage (S1) is penetrative and homogeneous enough to allow the split of the rock in thin, regular and flat tiles.

Quarries

Nowadays, only a few quarries are still working in the area. The most important are the historical quarries of Engorduro and El Castillo, operated by the company Naturpiedra, employing between 40 to 50 workers out of the company's total of 150.

Engorduro is one of the oldest mining explotations in Segovia, with an estimated surface of 90 hectares, and proven reserves of roofing slates for, at least, 2 milion metric tons. In turn, El Castillo has a surface of 10 hectares, with proven reserves of 500.000 metric tons.

The factory has incorporated the lastest advances in natural stone processing, so in addition to roofing slates other materials are manufactured, such as ashlars, tiles, blocks and chips. In addition, there is a special line for producing historical formats, which are used in restorations.

Quarry, Bernardos

Architectural and cultural impact

Spain has been, since the 60s of the last century, the world's leading producer of slate for roofs. The starting point of this industry dates back to the opening of the Bernardos quarries.
At that time, expert craftsmen from France and Belgium moved to Segovia to work and teach the locals the art of artisanal slate production.
Some of them married and remained in Bernardos, founding lasting dynasties of slate makers. Today there are still descendants of these slate masters living in Bernardos.
Therefore, Spanish slate architecture is influenced by the Franco-Belgian School, unlike the German School, which uses different formats and installation systems.
The first building in Castile that had a slate roof „in the Flemish way" was the Casa del Bosque de Valsaín, completed in 1562. Later, the Palacio del Pardo, current residence of foreign leaders when visiting Spain, the Alcázar of Toledo, and the Monastery of El Escorial.
From the architectural point of view, new construction techniques for roof frames, necessary for the stratification of slates, were incorporated into Spanish architecture.
During the following centuries, the phyllite industry became one of the main economic drivers of the region, along with agriculture and livestock.
At the beginning of the 20th century, production experienced a decline, due to the Spanish Civil War and changing architectural trends.
However, towards the 60s of the last century this industry was revitalized by the new operation of abandoned quarries and a new interest in vernacular architecture.
Today, this activity once again leads the development of this region of Spain.

Historical photo, Bernardos

Main reference

Cárdenes, V., Rubio, aA. & Ruiz de Argandoña, V. G. (2019): Roofing slate from Bernardos, Spain: a potential candidate for global heritage stone.- Episodes Vol. 44, 1, 3-9.

" An IUGS Heritage Stone is an IUGS designated natural stone that has been used in significant architecture and monuments, recognized as integral aspects of human culture."

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