



# Walking on Geodiversity: the Artistic Stone-Paved Sidewalks of Lisbon (Portugal) and Their Heritage Value

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## Abstract

Sidewalks are not a trivial topic. They are a fundamental element of streets, the main public spaces in urban environments. In modern cities, paving materials are mostly artificial. In Portugal, stone-paved sidewalks are still prevalent and quite characteristic. Walking down a street, you do not need to lift your eyes off the ground to know you are in Portugal. In nineteenth-century Lisbon, a new type of pavement was introduced, the *calçada portuguesa*, the Portuguese artistic pavement mainly made with white and black limestone or basalt. This pavement is examined herein. More than simply highlighting its geological components, the different meanings and values of the *calçada* will be discussed from a semiotic perspective. It will also be debated how this geocultural heritage asset became key in shaping the city's image. How it boosted Lisbon's memorability, thus generating a strong sense of place among its inhabitants. So much so that these days the *calçada* patterns are everywhere, from table ware to post stamps, and even on socks. And yet, the long-term survival of the artistic pavement may be in peril. To ensure its preservation, the *calçada portuguesa* was recently included in the Portuguese Cultural Heritage list, a crucial step towards UNESCO world heritage status. However, in the document ratifying its newly attained status, the geological component of the pavement is mostly neglected. To maximize the conservation effort, the many meanings and heritage values of the *calçada*, namely the geological ones, should be actively involved, this work hopefully contributing to this end.

**Keywords** Urban geodiversity · Lisbon · Portugal · Pavements · Sidewalks · Heritage value · Sense of place

## Introduction

People walking down a street, going on with their lives, pay attention to little else but the sidewalk pavement, the ground floor of buildings, and what is going on at street level in the space around them (Gehl 2011). Therefore, sidewalks are not a trivial topic. As a fundamental element of streets, the main public spaces in urban environments, they play a major role in modern cities. As Jacobs (1961:29) so aptly put it: "Streets in cities serve many purposes besides carrying

vehicles, and city sidewalks – the pedestrian parts of the streets – serve many purposes besides carrying pedestrians."

These days, in most cities, especially in western countries, sidewalks are made of asphalt, bricks, concrete, or slabs of any other artificial material. Not in Portugal. Traditional stone-paved sidewalks are still the norm all over the country. They may take different forms in different regions, use local or exotic rocks, they may employ different techniques, be plain or elaborate, but they are still stone pavements (Fig. 1). In Lisbon, the country's capital, beginning from the mid-nineteenth century onwards, paved sidewalks were taken to a higher level with the introduction of the artistic *calçada portuguesa* (Fig. 1B). Later, this type of mosaic pavement was introduced in several cities around the world, namely in those places where Portuguese cultural influence is relevant, e.g., in Brazil and Mozambique.

There have been attempts to replace these pavements with cheaper, easier to clad and maintain artificial substitutes, but with little success. Despite the infamous reputation of

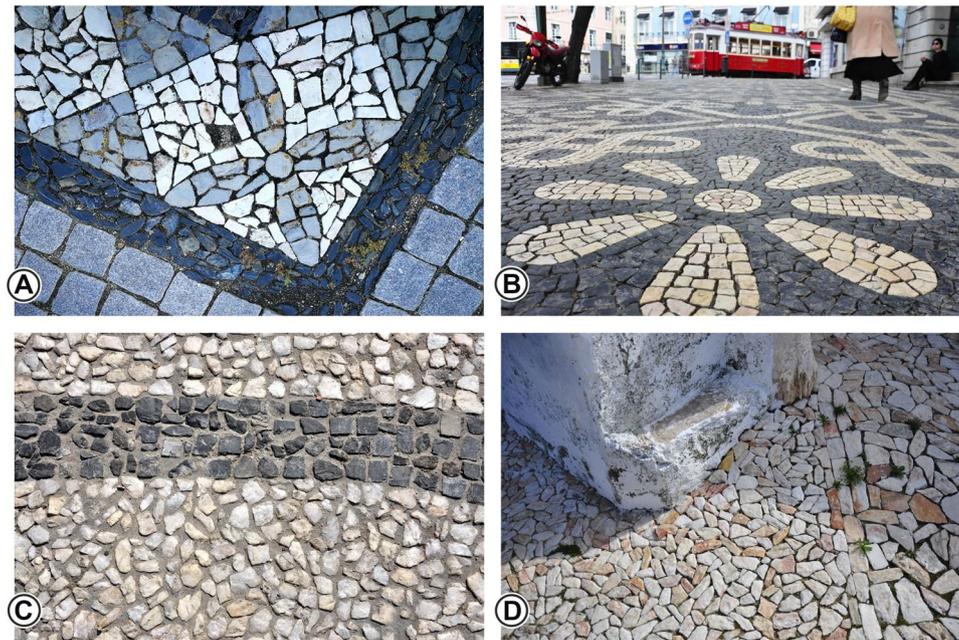
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**Fig. 1** Traditional sidewalk pavements from Portugal, a few examples. **A** Churchyard pavement at Vila de Cabeção (Alentejo region, southern Portugal) featuring different lithologies; local (black lydite and white marble) and regional, national ones (grey and black limestone and diorite). **B** The artistic pavement of Lisbon (Estremadura, central Portugal), with white, black, and pink limestone, and, in older pavements, local basalt (Silva 2016b). Note that the shape

of the small stone setts (4–5 cm across) is not regular, being fashioned according to the desired final effect, as seen in the center of the rosette. **C** Guimarães (Minho, northern Portugal), sidewalk with local white milky quartz and miscellaneous dark rocks, mostly black limestone from the Estremadura Calcareous Massif. **D** Pavement in Estremoz (Alentejo) prominently featuring the local white and pink marble

the *calçada* as the nemesis of stiletto heels and the constant grumbles about poor maintenance, the new pavements are often not to the likings of local populations. Moreover, they are unremarkable. As a result, they did not become a recognizable and memorable part of the local urban landscape.

Expanding Jacobs' (1961) line of thought to the abiotic nature, one could argue that geodiversity serves many purposes besides providing humanity with geological resources (Gordon 2012; Gray et al. 2013). In Lisbon, the stones used in the artistic sidewalks end up representing a lot more than just building materials. This unique form of paving fuses geodiversity with national and local history, world influences, the sociology of urban spaces, and sense of place. It is as typical of Lisbon as the local custard tarts, the tile clad façades or the pervasive *liós* Cretaceous limestone. This is elegantly highlighted by Leutzsch (2014:182) when he characterizes Portuguese identity as *glocal*, i.e., globalized and yet still distinct in terms of a national character, using artistic pavements to illustrate it: "(...) some might have walked under the jacaranda trees in Lisbon, imported from the Orient, on the *calçada portuguesa* – the tiled Portuguese pavements – showing waves or coats of arms from all around the world (...)."

The economic and cultural values of geodiversity expressed in city pavements have been discussed in, e.g.,

Gray (2004), using the example of Funchal sidewalks (Madeira Island, Portugal). Gray (2019) and Frigerio et al. (2020) focused on the geodiversity of pavements in Brazil, namely the famous sidewalks of downtown Rio de Janeiro. Rajchel (2008) covered the historic pavements of Cracow (Poland). From a different perspective, the ichnological and science popularization aspects of the Araraquara sidewalk flagstones in Brazil were highlighted by Francischini et al. (2020).

Similarly, there are numerous works on the Portuguese artistic pavement focusing its history, techniques, and designs (Bairrada 1985; Henriques et al. 2009; Remesar and Esparza 2014; Remesar and Esparza Lozano 2014; Fernandes et al. 2017; Kremer 2018; Matos 2004, 2019–20, 2020; Santos 2022). The symmetry of its motifs, examined from a mathematical point of view, as well as its numerical modelling, is also a popular theme (e.g., Waintraub and Celes, 2012; Carvalho et al. 2016; Silva 2016a). Various geological aspects of these pavements have been the subject of previous works. Typically, these studies are centered on the origin, characteristics, extraction, transformation, and use of its geological building materials (e.g., Martins et al. 2007; Duarte 2019–20; Rocha et al. 2020). Some emphasize its educational potential as a teaching resource (Marta and Almeida 2006; Silva 2016b; Silva and Pereira 2021)

or as a prominent element of urban geodiversity in science popularization activities (Rodrigues and Agostinho 2016; Pereira and Lopes 2019). Nevertheless, in all these works, geodiversity values other than the economic or educational ones are seldom discussed.

Other works approach the theme from an urbanistic, architectural, and even sociological point of view, highlighting the role of city pavements in urban planning and as an important element of local identity (Esparza 2013; Esparza Lozano 2014; Lisboa 2011; Remesar and Esparza 2014; Remesar and Esparza Lozano 2014). However, these works do not address the geodiversity of the *calçada portuguesa*. In them, no link is made between the geological aspects of the artistic pavements and their cultural and urban impact. A glaring example of this is that in the submission of the *calçada portuguesa* for inclusion in the Portuguese Intangible Cultural Heritage list (ACP 2021) the geological nature of the elements forming the pavement is almost completely overlooked.

This paper will discuss the artistic stone-paved sidewalks of Lisbon. The discussion will be focused not only on their geological components but also on what different meanings are assigned to them by city dwellers. Moreover, it will be debated how artistic pavements soaked into people's lives and memories, as well as into local values and culture, thus making them key in shaping the city's image and instrumental in the development of a sense of place among its inhabitants.

## The Artistic Sidewalks of Lisbon, a Brief Introduction

### The History of Modern Inlaid Stone Pavements

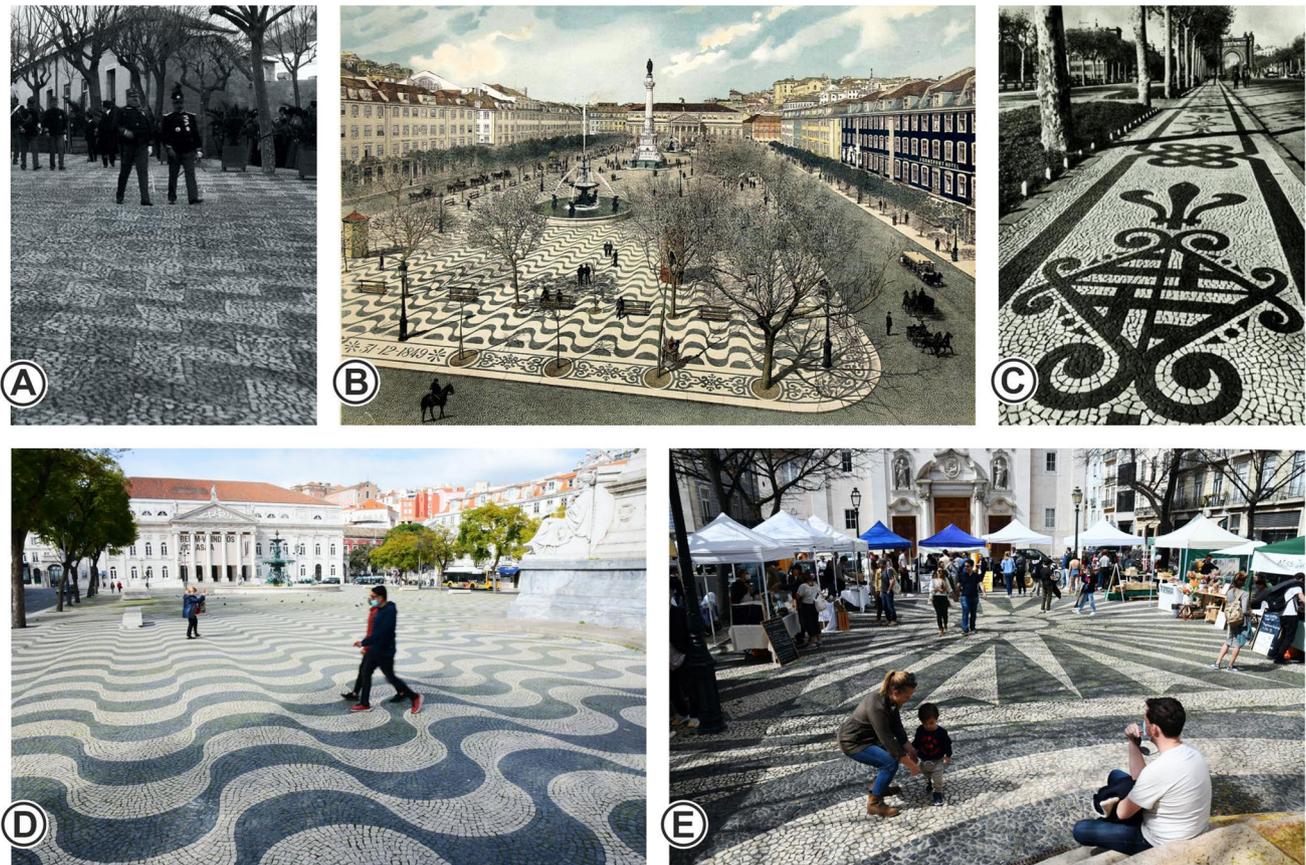
Facts and legend often walk hand in hand in local history. As far as the legend goes, extensive paving of Lisbon's streets started in early sixteenth century because of an Indian rhino named Ganga (Almeida 2021). The very same one immortalized in Dürer's 1515 famed print of a rhinoceros, the first of his kind to be admired in Europe since Roman times. The animal was a diplomatic gift from Muzaffar Shah II, the sultan of Cambai (Gujarat), to Afonso de Albuquerque, the Portuguese Viceroy in India. Subsequently, it was passed to King Manuel I of Portugal, arriving at Lisbon on 1515. One year later, the magnificent beast was sent as a present to Pope Leo X as a diplomatic stunt (Chitalwala 1990; Bedini 2006; Kahlow 2018). However, Ganga never made it to Rome. The unfortunate behemoth perished when the ship he travelled in went down off the Italian coast of Genoa during a storm (Fontoura da Costa 1937). Allegedly, upon its arrival to Lisbon, Ganga was to be exhibited through the streets of

Lisbon. To prevent the richly adorned beast, as well as the illustrious participants of the parade, from being spattered with Lisbon's notorious dirt, King Manuel I ordered that the route be paved. The fact is that the extensive stone paving of Lisbon's streets indeed began around the turn of the sixteenth century, but it already had started a few decades before the arrival of Ganga (Estevam 1959; Almeida 2017).

The Portuguese artistic paving now known as *calçada portuguesa* originated much later in mid-nineteenth century. The first pavement of this type was laid down in Lisbon in 1842 in the parade ground of the São Jorge Castle, back then — according to Andrade (1960) — the home of the Batalhão de Caçadores 5 (5th Battalion of Light Infantry), an elite rifleman unit formed during the Peninsular Napoleonic War. The paving was ordered by lieutenant general Eusébio Pinheiro Furtado, the Governor of the castle, and laid by convicts sentenced to civil service in the fortress (Castilho 1893). A simple black and white zigzag pattern was used (Fig. 2A). The new pavement was an immediate success (Bairrada 1985; Matos 2011). As Paes (1883: 1) illustrates: "It was a novelty; it made a sensation. There were pilgrimages of visitors to the São Jorge Castle to admire the mosaic pavement; most people understood that the system was good, beautiful, inexpensive and that it should be widespread." Paes (1887: 24) continues: it "(...) is the most durable, the most economical and the most beautiful system that can be used for this purpose, and it also has a truly national character, because it is not found in any other country."

Following the enormous excitement surrounding the castle's innovative pavement, Eusébio Furtado suggested Lisbon's recently renovated Rossio central square, later formally renamed Dom Pedro IV Square, should be similarly paved. His proposal was accepted by the Municipal Council, and the paving works started in the summer of 1848. This time, the pattern used to cover the central area of the square was, in the words of Castilho (1937:111): "(...) those black and white waves, which produce such wonderful effect, and which interested so much the generation of that time.", i.e., the wavy design now known as Wide Sea (*Mar Largo*), an expression borrowed from Camões' (1571) epic poem *Os Lusíadas* (The *Lusiads*), and a tribute to Portugal's seafaring traditions. Rossio's paving was completed on the 31st of December of 1849, mostly taking advantage of the cheap labor provided by the convicts (Fig. 2B). Although the original pavement has been removed in 1919 to improve car traffic (Johnston 1922; Castilho 1937), to this day, Rossio shows an extensive Wide Sea pattern (Fig. 2D), revamped after the 2001 rehabilitation of the square (Valada 2001).

Soon after the successful renovation of the Rossio Square, other emblematic public spaces in downtown Lisbon were paved using the new mosaic technique. In 1889, the black and white artistic pavement expanded to the central



**Fig. 2** Historical Portuguese pavements. **A** King Carlos I on the parade grounds of the Caçadores 5 barracks in the São Jorge Castle, 1904. The original zigzag pattern of the pavement is visible. Image from the Arquivo Municipal de Lisboa, CML (PT/AMLSB/ANV/000412). **B** The Rossio Square in central Lisbon circa 1890 showing its characteristic Wide Sea inlaid pavement. Image from the Museu da Cidade de Lisboa, CML, EGEAC (MC.GRA.1460). **C** The

vanished late nineteenth-century Portuguese pavement in Barcelona, in the Saló de San Joan, present-day Passeig de Luíís Companys, boasting the Barcelona coat of arms. Image from Soldevila (1952). **D** The Rossio in 2020 during the COVID-19 lockdown. The mosaic pattern is the same, but the pavement is not the original one. **E** The ‘rising sun’ pavement at the São Paulo Square in 2022. This is one of the oldest in Lisbon, preserving the use of small basalt setts

Liberdade Avenue, and six years later, it was adopted as the standard sidewalk paving technique in Lisbon (Bairrada 1985; Silva and Sousa 2019).

The modernization of the Portuguese capital initiated in the Rossio Square introduced a new perspective on the planning of public spaces in nineteenth-century Lisbon. Squares and boulevards started being designed and renovated to include dedicated walking and leisure areas meant to be enjoyed by pedestrians (Barradas 2004). Consequently, the Portuguese artistic paving became an organic element of this novel approach to city planning and of the new image of Lisbon (Fig. 3).

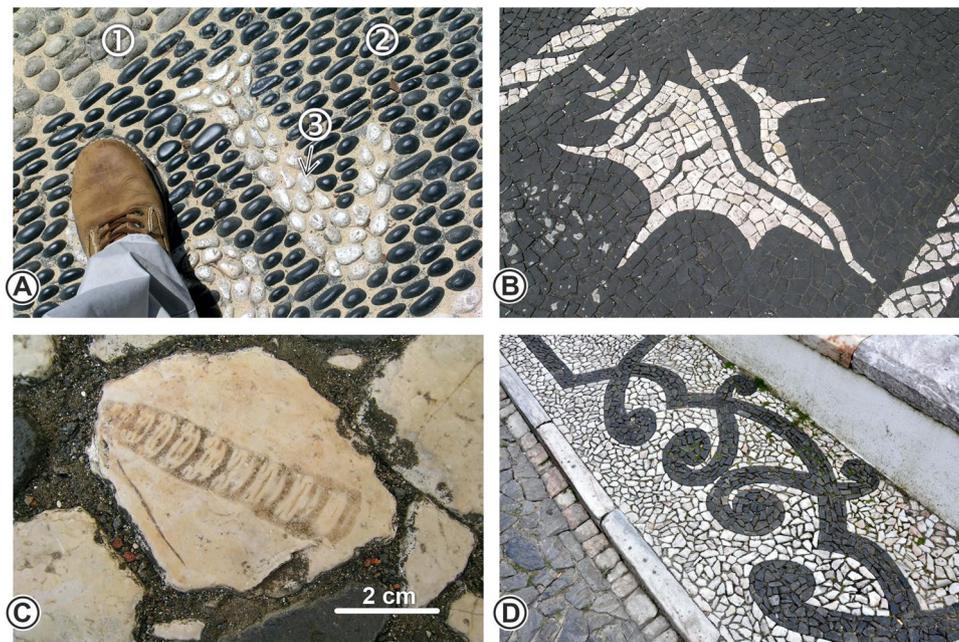
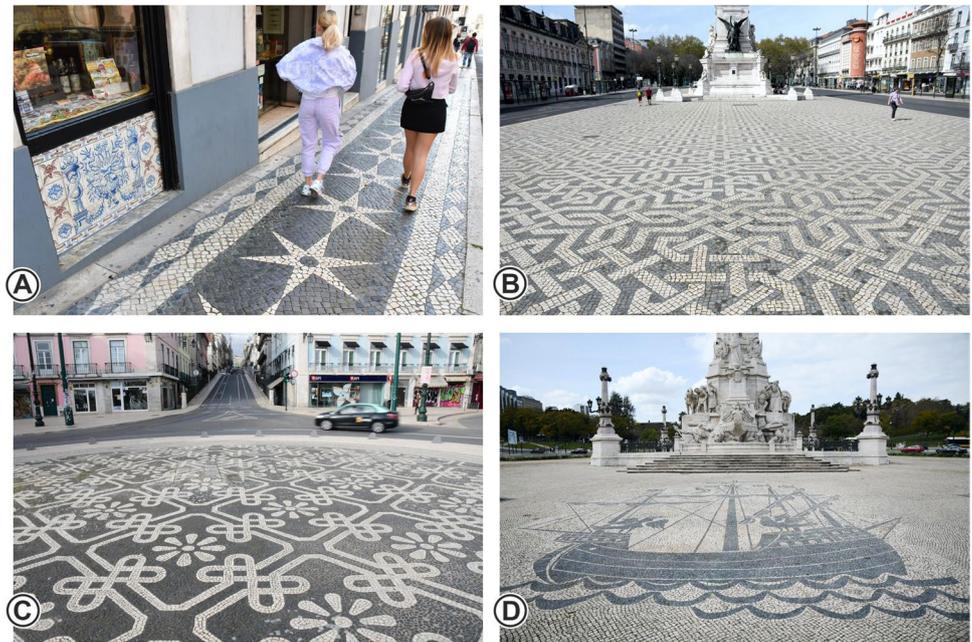
### The *Calçada* Across Portugal, a Few Examples

After its success in Lisbon, the use of the mosaic pavement spread rapidly all over the country (Bairrada 1985; Henriques et al. 2009). The *calçada* showed remarkable

adaptability and was easily tailored to regional geological contexts and local motifs. In the Atlantic volcanic archipelago of the Azores, the Portuguese pavement uses both native and exotic stone. It is clad with local basalts and white limestones from Jurassic-Cretaceous formations of mainland Portugal easily recognized by their fossil content, e.g., nerineid gastropods absent in these upper Miocene to present-day Atlantic islands (Fig. 4C). The need to import the white limestones led to a curious color inversion in *calçada* designs. Unlike typical Lisbon pavements, in the Azores, the backdrop is set with black basaltic sett stones, locally abundant, the drawings produced with the white ones. In the island of Santa Maria, adjusting to local maritime themes, the pavements exhibit ships, fishes, and seashells (Fig. 4B).

In Estremoz, in the Alentejo region of southern mainland Portugal, another geological variant of the *calçada* occurs (Fig. 4D). Here, the pavements are built with black and white local rocks. The white ones made of Cambrian-Ordovician

**Fig. 3** Artistic pavements in downtown Lisbon, a few examples. **A** The starry stone carpet of Alecrim Street in downtown Lisbon showing the six-point star motif, also known as *Estrela do Milhões*, a common sidewalk pattern. **B** The intricate arabesque tapestry of the Restauradores Square. **C** The elaborate rosettes and bows pattern of the Duke da Terceira Square during the 2020 COVID-19 lockdown. **D** The coat or arms of Lisbon, a sailing ship with two crows facing each other and sitting on opposite sides of the vessel, in the Marquês de Pombal Square (see also Fig. 8B)



**Fig. 4** Pavements across Portugal. **A** The artistic pavement of Porto Santo (Madeira Archipelago) made of local pebbles; 1—gray trachyte; 2—black basalt; 3—white Miocene coral limestone. Several white pebbles show a pitted surface, the effect of the voids of the individual colonial coral corallites on their surface. **B** Portuguese artistic pavement in Vila do Porto (Santa Maria Island, Azores) depicting a gastropod shell using white limestone cobble stones on a

black basalt backdrop. **C** Detail of a white limestone sett stone from mainland Portugal in a Vila do Porto pavement showing a longitudinal cross section of a Jurassic-Cretaceous nerineid gastropod. **D** Portuguese artistic pavement on a sidewalk in Estremoz (Alentejo region), using local white Cambrian-Ordovician marbles and black Precambrian Mares Formation lydites. In pictures **B**, **C**, and **D**, the larger setts have 5–7 cm edges

Estremoz Marbles, a UNESCO Global Heritage Stone, and the black ones representing Precambrian Mares Formation lydites of the SW Iberia Ossa-Morena Zone (Lopes and Martins 2015; Menningen et al. 2018; Rui Dias, verbatim 2022).

Traditional stone pavements — aside from the typical *calçada portuguesa* — exist all over Portugal (Fig. 1). In the Atlantic archipelago of Madeira, for instance, a distinctive local type of black and white cobblestone pavement occurs,

akin to the *calçada* in visual effect, but using completely different building materials, whilst in Lisbon, the inlaid mosaic pavements are made of small fashioned limestone blocks, i.e., of setts, 4 to 6 cm across, specially fashioned and laid to produce the artistic motifs (e.g., Fig. 1B), in the small island of Porto Santo (Madeira archipelago), local black, white, and grey pebbles are used to pave sidewalks and squares (Fig. 4A). Collected on the shoreline or in creeks, they represent different lithologies. The white ones are coral limestones, the black ones basalts, and the grey pebbles trachytic rocks. All are local, and Miocene in age (e.g., Lyell 1854; Santos et al. 2011; José Madeira, verbatim 2022). Similar artistic pavements occur extensively in Madeira Island (Silva 2017; Silva et al. 2022).

### The Portuguese Artistic Pavement Around the World

One could imagine that the importance of the *calçada portuguesa* was restricted to the capital of Portugal where it originated or, at most, extend across the national territory. Nothing could be farther from the truth. Having forged the first global colonial empire (Crowley 2015), the Portuguese cultural impact, among other less benign impacts, was felt worldwide since the fifteenth century. As it turns out, the Lisbon patterned pavement made its way to the four corners of the globe: from Brazil to Mozambique, and from the African islands of Cape Verde to Macao in China.

However, the first city outside Portuguese territory which laid down a *calçada* style pavement was Barcelona (Esparza Lozano 2014). In late nineteenth century, the need for adequate pavements for pedestrian and vehicle traffic led the Municipality of Barcelona to search for new paving techniques. One of the techniques tested was the Portuguese mosaic (Esparza 2013; Esparza Lozano 2014). In 1896, 500 m<sup>2</sup> were laid down in the Saló de San Joan — present-day Passeig de Lluís Companys — on the sidewalks between the triumphal arc and the monument to Rius and Taulet (Fig. 2C). Despite the success of the test, no further streets in Barcelona were paved with *calçada*.

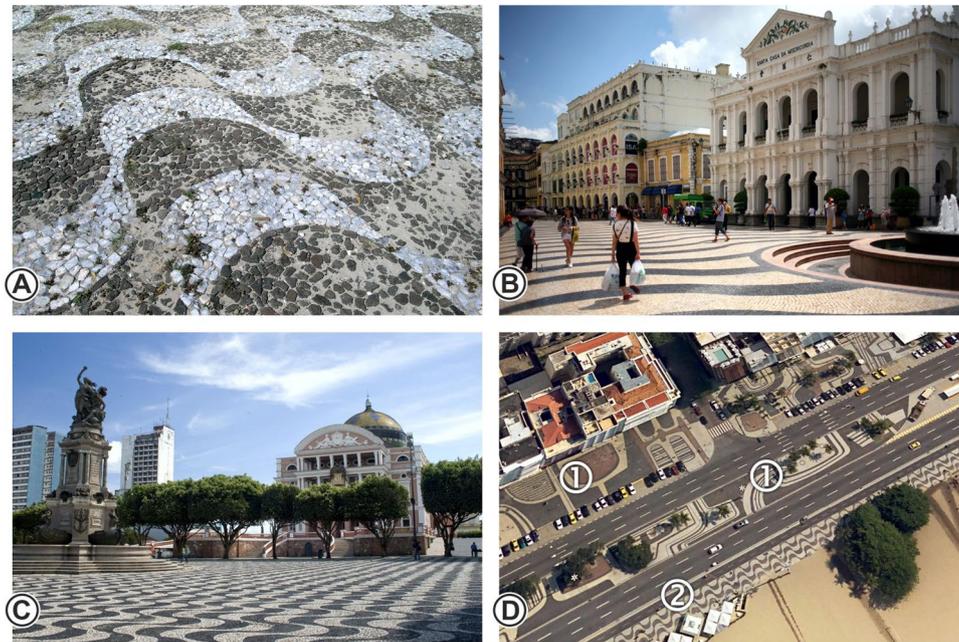
In 1900, a team of Portuguese pavers from Lisbon, the *calceteiros*, was sent to Paris to demonstrate their craft at the Exposition Universelle. This was an initiative lead by the Municipality of Lisbon, whilst the Barcelona experiment was a private business undertaking. The Paris demonstration was followed by others all over the world: Manaus (Brazil), in 1904, Rio de Janeiro (Brazil), 1906, Cape Town (RSA), 1909, Genoa and Naples (Italy), 1913, Seville (Spain), 1929, etc. (Passeios de Lisboa 1939).

Since early twentieth century, the Portuguese pavement has been used in many places around the world, especially where an important Portuguese community exists, emphasizing its strong identity value. In Brussels, for instance, the Fernando Pessoa Square (an early twentieth century Portuguese poet) is

paved with *calçada portuguesa*. In the USA, in Sausalito (CA), a town geminated with the Portuguese town of Cascais, the local Cascais square is paved with Portuguese artistic mosaic pavement. The patterns employed are extremely diverse. However, by far, the most iconic and widespread of them all is the Wide Sea pattern. It may be found from Mozambique (Fig. 5A) to Macao (Fig. 5B), and Brazil (Fig. 5C–D). All of these are associated with UNESCO World Heritage sites stressing the international heritage relevance of the *calçada*. Also in Alicante, Spain, on the 1955 pavement of the famous maritime promenade of the Passeig Esplanada d’Espanya (Alicante 2017), and in many other towns (e.g., Olivenza), local adaptations of the Lisbon *Mar Largo* pattern are used in pavements of all sorts, not just those using *calçada*.

The Portuguese pavement has proven itself to be easily adjustable to exotic urban settings. It allowed the use of the typical Lisbon patterns and the creation of new ones more in tune with local needs and aspirations. It is a typically Portuguese craft that due to its artistic plasticity and strong visual impact quickly become a prominent feature of many urban environments worldwide.

The iconic 4 km long Copacabana beach promenade (Rio de Janeiro, Brazil) is a fine example of the *calçada*’s artistic adaptability. It was originally paved in the early twentieth century using the classical Lisbon wavy pattern (Fig. 5D). This pattern was prominently featured in the 1942 Walt Disney animation film *Saludos Amigos*, in which two famous showbiz birds, Donald Duck and the local parrot José Carioca, engage in a lively dance having the wavy design of the Copacabana pavement as backdrop. Much later, in the 1970s, the promenade was widened, and its pavements redesigned by the acclaimed Brazilian landscape architect Roberto Burle Marx, at a time when the city was remaking its image (Siqueira 2021). Today the Copacabana Promenade sidewalks featuring Roberto’s designs are an important part of an internationally understood identity for downtown Rio (Floriano 2013), a key element in its legibility as an urban space. Marx kept the original Wide Sea pattern, and introduced modernist abstract designs of its own inspired by Brazilian indigenous art. Interestingly enough, when the work of Marx in Copacabana is evoked (e.g., Waintraub and Celes 2012; Gray 2019; Lifson 2019), often the ‘innovative’ wavy pattern is mentioned, rather than his actual late twentieth century designs, proving that more than 150 years later, the catchy *Mar Largo* pattern, the original one, still has got it.



**Fig. 5** Portuguese Wide Sea pavements around the world. **A** Wide Sea pattern at the São Paulo Square, Mozambique, part of the Island of Mozambique UNESCO World Heritage Site. White quartz and black basalt. **B** Adapted Wide Sea pattern at the Leal Senado Square, Macao, part of the Historic Centre of Macao UNESCO World Heritage Site. Image from Paolobon140, Wikimedia Commons. **C** Wide Sea at the São Sebastião Square, connected with the Manaus Teatro Amazonas opera house (in the foreground), Brazilian National His-

torical Heritage and part of the Amazonia Theatres submission to the UNESCO World Heritage List. Image from Pedro Angelini, Wikimedia Commons. **D** The Copacabana beach promenade, Rio de Janeiro, part of the Carioca Landscapes between the Mountain and the Sea UNESCO World Heritage Site; 1—the modern designs of Roberto Berle Marx; 2—the traditional Wide Sea pattern. Image from Google Earth

## The Geology of the Artistic Pavements of Lisbon

### Preamble

The *calçada* is an urban cultural artifact made of stone; therefore, its geology is paramount. Traditionally, the Portuguese artistic pavements in Lisbon are created with white and black stones. However, to produce some artistic designs, additional rocks of different colors may be employed. Moreover, in the course of its history, different lithologies have been used. Interestingly, the *liós* (or *lioz*), the ever so characteristic whitish cretaceous limestone of Lisbon’s noblest architecture and a UNESCO Global Heritage Stone Resource (Silva 2016b, 2019a, b, 2020; Pacheco and Cachão 2021), is absent in the *calçada*. Being a pricey material, the *liós* is seldom used in outdoor flagstone pavements. However, it is relatively common in refined indoor settings.

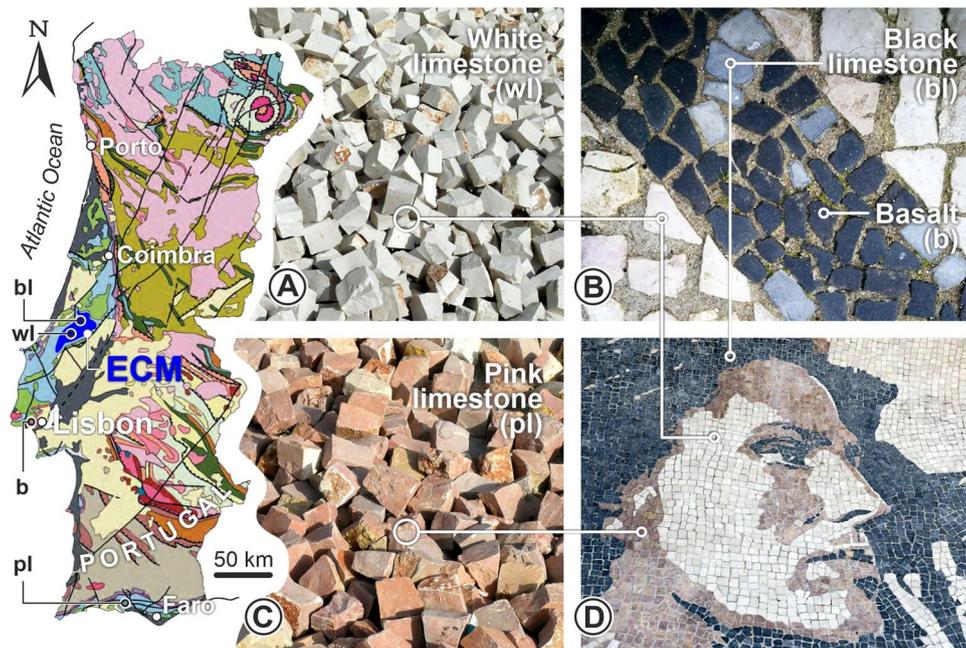
The typical black and white patterns lead people to assume that the white stones are limestone and that the black ones basalt. However, although basalt was present in earlier pavements, it was quickly replaced by black limestone. The limestones — both the white and the black ones — currently originate from a restricted region located some 90 km north

of Lisbon (Fig. 6A, B, D). The basalt used in older pavements is local. It was quarried in numerous locations in and around Lisbon. A third, less common element, is the light-brown or pink limestone. This limestone comes mostly from the Algarve (Henriques et al. 2009), in southern Portugal (Fig. 6C, D).

### The Black and White Limestones from the Estremadura Calcareous Massif

These days, the black and white limestones used to produce the small stone setts of the *calçada portuguesa* come mainly from the Estremadura Calcareous Massif (ECM). This geomorphological unit encompasses the Candeeiros (610 m) and Aire (679 m) mountain ranges and, in between the two, the Santo António and São Mamede plateaus (Fig. 6). Located roughly 75 to 110 km north of Lisbon, the ECM is the most important limestone massif of Portugal (Rodrigues 2020).

Most of the white or beige limestone quarries for pavement stone in the ECM are located in and around the Pé da Pedreira village, between Alcanede and Porto de Mós, in the Candeeiros Mountain Range. The name *Pé da Pedreira* itself represents an interesting example of the influence of



**Fig. 6** Rocks commonly used in the artistic pavements of Lisbon and their origin in Portugal. **A** The Middle Jurassic white or beige limestone from the Estremadura Calcareous Massif (ECM). **B** A stretch of pavement showing different lithologies: white, black, or grey Middle Jurassic limestones from the ECM and Upper Cretaceous basalt from the Lisbon region. **C** The Upper Jurassic pink limestone of Albufeira, Algarve. **D** Artistic pavement in Lisbon depicting Amália Rodrigues, celebrated Portuguese *fado* singer, designed by Vhils, the Portuguese street artist Alexandre Farto and several master pavers, including

Jorge Duarte, using white, black, and pink limestone setts. wl — origin of the white limestone (Pé da Pedreira region); bl — black or grey limestone (Alqueidão da Serra); b — basalt (Lisbon region); pl — pink limestone (Albufeira in the Algarve). ECM, Estremadura Calcareous Massif (marked dark blue). Geological map of Portugal showing the origin of the materials used in the Portuguese *calçada* adapted from Martins (2012). In all pictures, the larger sett stones are 4–6 cm across

geodiversity in regional toponomy, directly alluding to the local stone extraction activity, as it means ‘foothill of the quarry’. In this area, sedimentary sequences are represented by extensive horizontal to sub-horizontal metric to decametric strata, allowing the selective quarrying of the limestone beds best adapted to producing pavement stone (Rocha et al. 2020).

The stone is extracted from the Serra de Aire Formation and from the Pé da Pedreira Member of the Santo António-Candeeiros Fm (sensu Azerêdo 2007). The former corresponding to the Serra de Aire Micritic Limestones Fm of Manuppella et al. (2006), and the latter to the Pé da Pedreira Limestones Fm in Manuppella et al. (2006). In older works, such as Carvalho (1997), these local Pé da Pedreira units were included in the Valverde Fm. Both the Serra de Aire Fm and the Pé da Pedreira Member are Middle Jurassic, Bathonian, in age (Azerêdo 2007).

The pavement stone quarried in this region is a compact, biopelmicritic wackestone, white to beige, sometimes greyish, texturally homogeneous with a very fine matrix, mainly composed of micritic calcite (Carvalho 1997; Rocha et al. 2020). These carbonates were deposited in lagoonal to very shallow low energy marine environments,

in intertidal conditions (Carvalho 1997; Manuppella et al. 2006). This interpretation is supported by the fact that in the Vale de Meios limestone quarry, a mere 1 km northeast of the Pé da Pedreira village, dozens of theropod dinosaur tracks were identified (Santos et al. 2008; Santos 2016). According to Azerêdo (2007), these dinosaur tracks occur in the lower set of limestones of the Serra de Aire Fm. Occasional macroscopic body fossils of invertebrate animals are also found, mainly indetermined bivalves and nerineid gastropods.

The quarrying activity in the ECM is vital for the regional economy, involving from hundreds of small and artisanal quarries operated by the owner to a few rather large and industrialized operations employing tens of workers. These quarries offer valuable opportunities to finding well-preserved and extensive dinosaur tracks and, at the same time, pose significant challenges to their study and conservation. Currently, the outstanding Vale de Meios and Pedreira do Galinha sites — both former quarries — are protected as Natural Monuments within the Aire and Candeeiros Mountain Range Natural Park. The Galinha site, boasting a 147 m long sauropod track, one of the longest tracks of this type in the world, offers a visitor center and guided tours. It receives

tens of thousands of visitors every year (Santos et al. 2008, 2009; Santos 2016).

The black limestones are currently quarried at Alqueidão da Serra, in the Santo António Plateau of the ECM. These limestones are part of the ‘Cabaços and Montejunto Beds’, Upper Jurassic, Oxfordian, in age (Manuppella et al. 2000; Rocha et al. 2020). They constitute a monotonous carbonate formation deposited in a protected internal platform low energy marine environment. The compact calcitic limestones of Alqueidão show higher concentrations of S, Si, and Fe than the white counterparts from Pé da Pedreira. Occasionally they include scattered millimetric crystals of sulphides, such as pyrite and chalcopyrite (Rocha et al. 2020). The unique features of these limestones are the result of contact metamorphism induced by a local Early Cretaceous doleritic intrusion (Aires-Barros 1979; Manuppella et al. 2000; Rocha et al. 2020). The high organic matter content of the original rock coupled with the thermic influence of the intrusion resulted in a limestone with a characteristic black to dark-grey homogeneous color. No macroscopic fossils were ever reported from these limestones.

### The Pink Limestone from Albufeira, Algarve

Traditional artistic pavements employ black and white sett stones (Fig. 2A–B). However, to create more elaborate designs, pink limestones are sometimes used. That is the case of the tribute to the internationally renowned *fado* singer Amália Rodrigues laid down in the Alfama barrio of Portugal’s capital (Fig. 6D).

Presently, pink limestones are mainly extracted in the Escarpão quarry, in Albufeira, in the Algarve (Fig. 6). Although industrial quarrying at this site started in the 1950s, the records of stone extraction in the Escarpão estate, currently the main quarrying operation in the region, go back to the nineteenth century (Henriques et al. 2016). These limestones are part of the Escarpão Formation of Ramalho (1985, 2015), an Upper Jurassic, Kimmeridgian to lower Tithonian sequence of fossiliferous carbonate rocks reaching 500 m in total thickness. The formation outcrops both in the eastern and the western sectors of the Algarve Basin which occupies the onshore of the southernmost Portuguese territory, as well as part of the adjacent continental shelf in the Sagres region (south-westernmost Algarve). All the large limestone pits of the Algarve quarry the Escarpão Fm limestones for aggregates, pavements, and as dimension stone.

The Escarpão lithologies include beige and grey homogeneous compact limestones occurring in frequently bioturbated decametric to metric beds locally interbedded with marls, and pink to yellowish dolomitic limestones and dolostones (Ramalho 1985, 2015; Rocha et al. 1989). The rocks are fossiliferous, the assemblages commonly including macrofossils and bioclasts of corals, stromatoporoid-like

organisms, bivalves, and nerineid gastropods. The Escarpão Fm resulted from deposition in a shallow marine internal platform environment with low to medium energy (Ramalho 1985, 2015).

### The Basalt from the Lisbon Region

Originally, the black sett stones were made of basalt. In mainland Portugal, its use was soon abandoned in favor of black limestone because, being a very tough rock, it was — literally — very hard to break and more difficult to craft (Bairrada 1985; Cabrera and Nunes 1990; Henriques et al. 2009; Kremer 2018). However, to this day, basaltic stones may be found in older pavements (Fig. 2E, also in Silva and Pereira 2021, fig. 8).

Occurrences of basalt are common in the Lisbon region. They are part of the subaerial Volcanic Complex of Lisbon (VCL). The VCL reaches 400 m in thickness and records several episodes of effusive and explosive volcanism. It consists of basaltic lava flows interbedded with pyroclastic material and, occasionally, paleosoils yielding fossils of terrestrial organisms, lacustrine gastropods, and vertebrates (Ramalho et al. 2001). The VCL is dated Upper Cretaceous, Campanian–Maastrichtian, in age, *circa* 72 Ma (Ferreira and Macedo 1979; Palácios 1985; Pais et al. 2006; Manuppella et al. 2011). The geoheritage relevance of this volcanic unit is highlighted by the fact that the prismatic columnar jointing basalts exposed at the Aliança Operária Street in Lisbon were included in the municipal list of geomonuments (Pinto et al. 2010).

In historical times, the number of basalt quarries in Lisbon reached as many as 80. According to Pinto (2005), in the period between 1927 and 1978, basalt quarries still amounted to 6% of the extraction sites of geological building materials in the territory of the municipality. Currently, there are no active basalt quarries in Lisbon and most of the old sites are now completely gone, overgrown by the urban sprawl of the city. However, traces of these sites survive here and there, as in the Aliança Operária geomonument. To this day, basalt is extracted in Vialonga, some 15 km northeast of Lisbon, in the Moita da Ladra quarry, but no longer used for paving (Pinto 2005; Travassos et al. 2009).

## The Many Meanings of the *Calçada Portuguesa* and Its Heritage Value

### What Is (Heritage) Value?

Heritage is commonly defined as the set of elements — i.e., of heritage assets — of the natural and cultural environment, material or intangible, that any given group of people has discovered, created, or inherited from previous generations

that communities and societies believe are so important that should be preserved and passed to future generations (e.g., Logan 2007).

In line with the general understanding of heritage, Sharples (2002) defines geological heritage as the group of examples of geodiversity which may be especially identified as having conservation significance, i.e., that should be preserved and passed to future generations. On the other hand, for Brocx and Semeniuk (2007), in a nutshell, geoheritage encompasses those features of geology, at all scales, that are intrinsically or culturally important for research, teaching, or reference (nothing being said, explicitly, about conservation for future generations).

However, significance, importance, value, and by extension heritage value is not an intrinsic characteristic of things. It is not a quality of the heritage asset in itself, be it natural or manufactured, material, or intangible. Value is a social construct, a generic concept aggregating all those beliefs and ideas to which some valuational positive or negative meanings are attached (Mead 1976; Logan 2012). Therefore, as pointed out by Marx (1867), value does not stalk about with a label describing what it is. It is value, rather, that converts every product — or, in this case, every asset — into a social hieroglyphic. “(...) for the characteristic which objects of utility have of being values is as much men’s social product as is their language” (Marx 1867:167). The question of value, economic or any other kind, is thus bound up with the issue of meaning, of semantic significance. Goods, assets, and heritage assets are valuable in rather the same way words are meaningful (Turner 1990).

Semiotics, focused on the human activity of generating meaning, is a useful approach to debate representation and signification in a communicative context in as far as heritage in general is concerned (Peirce 1960; Ikegami 1991; Sebeok 2001; Saidi 2019). This has been attempted for geoheritage, in particular for the paleontological heritage, by Henriques and Pena dos Reis (2019). Key to semiotics is the meaning-making process in the wider sphere of communication. Humans are cultural beings whose operations and basic survival in all aspects of their lives are centered on evaluating things as well as on assigning meanings to them (Saidi 2019). Ikegami (1991) talking about language, a key human trait, calls this phenomenon ‘meaning-generating potentiality’.

When it comes to cultural heritage, human beings are usually both the actual makers of the heritage assets and the meaning generators. On the other hand, with regard to natural heritage, humans have the sole role of meaning creators. The natural assets themselves are products of nature. They have not been generated as meaning bearing elements, and they were not designed as elements of communication. Meaning is ascribed to them, a posteriori, by humans as a result of the ‘meaning-generating potentiality’.

From this point of view, for something to become a heritage asset (cultural, natural, intangible, etc.), there must be a certain group of people that finds it meaningful, i.e., that attaches some kind of meaning to it. The more people will find something significant, for whatever reason, the more important, more valuable, for the whole community that asset will be. Some things are meaningful for a large group of people for the same reason, e.g., precious metals, national symbols, local traditions, and cherished artists. Others are important for various, maybe smaller independent groups of people for very different reasons. A successful football player in the national team, for instance, is esteemed by many because of its athletic prowess. He is beloved by others because he is a national symbol, a source of national pride; admired by others because of his social status. Finally, for some people — football fans or not — he is important because they make a living from selling football merchandise.

The meanings assigned to heritage assets may be arranged in categories akin to those used for values as in, e.g., the ‘values of geodiversity’ discussed in Gray (2004). Categories such as economic value, cultural value, scientific, and religious values, among others, have been used. After all, value and meaning are intimately related, both being generated by humans. However, value is a concept used by those (e.g., scientists, politicians, and legislators) who evaluate the meaning of the (geo)heritage assets when dealing with (geo)conservation issues. It is used by experts when pushing for conservation. Meaning, on the other hand, is what is assigned to the heritage assets by people, by the community (including geoscientists). The values represent the meaning, they emanate from meaning, and meaning stands for the people that generated it. Therefore, the more different meanings a heritage asset congregates, the more important, the more valuable — for the entire community, not only for experts — it will be, for it is significant for a broader community.

### Meaning, Value, and Heritage Conservation

It is now consensual that conservation efforts that do not involve a wide group of people, i.e., that do not include the community, are probably destined to fail (e.g., Lurie and Hibbard 2008; Gruber 2010; Grodzińska-Jurczak and Cent 2011; Henriques et al. 2020). The traditional top-down approach to conservation, using a terminology that in itself embodies the problem (i.e., there is a top and a bottom, instead of a wide range of people equally and actively engaged in conservation), is a good example of this inadequacy. A restricted group of people at the ‘top’ identify the values (relevant from their point of view) and based on them proceed to conservation, which is then offered, sometimes enforced, to the ‘down’, i.e., the rest of the community (e.g., Logan 2015).



**Fig. 7** Expert-centered (A) and integrated community-centered (B) approaches depicted graphically in a yin and yangish sort of interaction involving both experts and the broader community (represented by the bigger yellow circle). An alternative visual model to the traditional non-integrated top-down and down-up triangular graphs. Experts are part of the community, albeit only a portion of it. The diversity of interacting meaning-generating groups of people in the community (including the experts) are represented by dotted and dashed circles of varied dimensions and colors

However, the actual preservation of a heritage asset is not a simple function of its value for any given group of people, but the result of the summation of all the values for all the people it is important for. In (geo)conservation issues, even when the primary argument for protection of a heritage asset is scientific, representing the commitment of the scientific community, it is crucial to identify and involve all groups of people assigning meaning to that asset. The more people are engaged in the conservation processes, no matter what their motivations are (e.g., scientific, professional, esthetical, cultural, ludic, religious, and economic), the more likely it will be successful. What is at stake here is not merely to win people's hearts and minds to conservation by instilling in them, e.g., a sense of pride in their own heritage (Grodzińska-Jurczak and Cent 2011). More than that, it is crucial to identify and understand what other meanings people assign to the heritage assets — different from those assigned by experts — and include them in conservation practices. This way, in a process that could be described as integrated or community-centered (Fig. 7), instead of bottom-up, the significance of said heritage asset will be maximized, increasing the chances of it being preserved.

## Meanings of the Portuguese Pavement in Lisbon

To captivate likeminded people is simple. This is common knowledge. For instance, for experts involved in science popularization or in conservation actions, it is easier to motivate people with a life experience that has exposed them to the type of language and argumentation scientists commonly use, therefore being more receptive to what is being conveyed. However, to reach the public, to get to a wider, more inclusive community, or to get through to distinct societal groups, one must appeal to different mindsets, to different concerns, and to different interests. In the end, people are motivated for conservation not by what they hear or see, no matter how clever and important the message may be, but by what they understand, by what they relate too. By invoking the heritage asset's different meanings, conservation advocates will reach to a wider audience, increasing the chances of conservation.

The Portuguese mosaic pavement makes an interesting case study for this semiotic, multiple meaning, integrated approach. Being a heritage asset that bridges the natural and the cultural, an urban artifact made of geological elements producing a powerful visual impact, the *calçada* soaked into people's lives and memories. As a result, it entails many different meanings, assigned by very different groups of people, all of them converging — literally — on a common ground: the artistic pavement.

The *calçada* has a geodiversity component, significant for people interested in Natural History or engaged in teaching Geology; it has an aesthetic meaning, attributed by those more artistically inclined; it has an historical and local identity connotation pertinent for a wide group of urbanites; and it has an economic meaning relevant to construction workers and contractors as well as to designers and souvenir shop owners alike, as there is a growing market for items depicting Lisbon's pavement patterns (Figs. 8 and 9). It has also an emotional side to it, evoking heartfelt memories and emotions related to different life experiences, positive and/or negative alike. For some, it even has a political meaning, as pavement sett stones were often used as makeshift ranged weapons by demonstrators in clashes with the riot police during the Salazar fascist dictatorship in the 1960s. Likewise, pavement stones were used as weapons in the May 1968 protests in Paris (Beardsley 2018) and in many other historical upheavals all over Europe (Watzlawik 2016; Provenzano 2020). It would not be difficult to find many other meanings assigned to the artistic pavements of Lisbon by city dwellers and visitors alike. It is precisely this wide array of meanings of the *calçada*, generated by so many different groups of people, that makes it such a relevant heritage asset.

**Fig. 8** The plurality meanings associated with the artistic pavements of Lisbon, a few examples. **A** Economic meaning. *Calceteiros* (pavers) at work. The pavement as livelihood and economic activity. Image from Zureks, Wikimedia Commons. **B** Identity meaning. The Lisbon coat of arms (see also Fig. 3D) depicted in the artistic pavement. **C** Aesthetic meaning. Intricate fleuron and palmettes pavement design beautifying the urban environment and appealing to the artistic sensibility of city dwellers. **D** Identification meaning. The artistic pavement pervasively used as a visual synecdoche for the entire city in urban walking guides



**Fig. 9** The plurality of functions and manifestations of the Portuguese artistic pavements and its patterns. **A** Identification and explicit communication. The name *Tavares*, a posh Lisbon restaurant, on the sidewalk next to its entrance. This type of ‘communicating pavement’, despite growing globalization and sophistication of the communication methods, is (still) common in Lisbon. **B** Identity. The *calçada* as a symbol of Lisbon; in socks and book covers, in exquisite Vista

Alegre porcelain coffee cups and in postal stamps. **C** The image of Lisbon. The *calçada* side by side with other recognizable Lisbon symbols; the *fado* song (Intangible Cultural Heritage of Humanity UNESCO), the yellow trams and the Tower of Belém (also World Heritage UNESCO). **D** Adaptations of the artistic pavement to contemporaneous communication, used to convey digital information by means of paved QR codes (Silva 2016a)

### The Artistic Pavement Gets National Heritage Recognition

In March 2021, the *calçada portuguesa* was put forward as

candidate for the Portuguese Intangible Cultural Heritage list by the Portuguese Artistic Pavement Association (*Associação Calçada Portuguesa*, ACP). Founded in 2017 by the Municipality of Lisbon, the ACP is devoted to protecting

and advancing the Portuguese artistic pavement, as well as to promote it internationally as a national cultural heritage asset and an identity element of Lisbon and Portugal. It aims to become a reference organization, both nationally and internationally, for the promotion of the *calçada portuguesa*. Besides the Lisbon and the Porto de Mós municipalities, the ACP congregates stone industry associations, the Union of the Portuguese Language Capital Cities, the Portuguese branch of the International Association for the Protection of Intellectual Property, and the University of Lisbon (ACP 2017).

In the proposal document (ACP 2021), the main focus is drawn to the cultural heritage aspects of the *calçada* (ACP 2021). Having in mind its inclusion in the Portuguese Intangible Cultural Heritage list, that is understandable. However, despite the plural character of the ACP and the geological basis of the artistic pavement, no geodiversity context whatsoever is offered for the *calçada*. No links are established between natural and cultural elements of the artistic pavement. There is not one single mention to Geology, geodiversity, or even to limestone, its chief building material. The word *pedra* (stone) is used only three times to state that the declining stone quarrying industry poses a serious threat to the survival of the artistic pavements and that, therefore, this issue should be further investigated.

As demonstrated above, the *calçada portuguesa* congregates a multitude of meanings. That is what makes it such an important element of Lisbon's identity. Therefore, its conservation and promotion, albeit centered on an obvious cultural heritage core, should gather as many meanings as feasible in order to appeal to the widest possible public. This implies that it would be beneficial to also include a geodiversity perspective in the effort to preserve and promote the Portuguese artistic pavements.

## The Artistic Pavements and the Image of the City

### What Makes a Place Memorable?

In his study about the visual quality of American cities based on the mental image which is held by its inhabitants, Lynch (1960:1) stated that: "Looking at cities can give a special pleasure, however commonplace the sight may be." Using the metaphor of language, Lynch goes on to explain that, as a printed text can be visually grasped as a pattern of decipherable symbols, so a legible coherent city would be one whose basic elements are quickly identifiable and easily grouped into recognizable patterns. As a result, every citizen has his own personal set of significant associations with the elements of his urban environment, having its image impregnated in personal memories and meanings.

Human existence is not possible without access to natural resources, both biological and geological (e.g., Gray 2004). Therefore, occupying a certain territory where resources exist, as well as being able to structure and recognize its physical characteristics, is key to survival. A variety of cues are used — sound, smell, touch, etc. — but since humans are highly visual creatures (Kaas 1992; Kaas and Balaram 2014), the physical signs we rely on the most to construct a mental map of our territory are the visual ones. This applies both to natural environments and to modern build, urban settings, the ones where — according to the United Nations (2018) — most of the human communities presently live in. This led Lynch (1960:9) to: "(...) the definition of what might be called *imageability*; that quality in a physical object which gives it a high probability of evoking a strong image in any given observer." i.e., that makes it recognizable and memorable. In Lynch's view, *paths*, channels in which people travel, including streets, sidewalks, and their pavements, along with *edges*, *districts*, *nodes*, and *landmarks*, are one of the five key elements that impact the imageability of a city. Positive imageability allows people to feel at home and develops community well-being, having an important impact in key elements of our quality of life such as urban happiness and place attachment (e.g., Hull 1992; Sepe 2015; Salvador 2015; Russel and Sullivan 2019).

All physical aspects of the city — from its skyline to building materials, street design, urban furniture, manhole covers, etc. — have a visual dimension. However, from its very beginning, on top of its utilitarian intent as an adequate surface for walking, the artistic pavement is designed to have visual impact. Elaborating on Lynch's concept, what makes the Portuguese pavement so important is its key contribution to the city's imageability (or legibility)! This has also been highlighted by Remesar and Esparza Lozano (2014). It is the variety of designs and uses of the pavement patterns which enables — for very different people and for very different reasons — the generation of clearly identified intensely structured, highly meaningful mental images of the urban environment (Figs. 1B, 2D, E, 3, 8B, C, and 9A).

### The Calçada Beyond Pavements in Everyday Life in Lisbon

Lynch (1960) interviewed Boston dwellers to assess the importance of city features in the generation of their image of the urban environment. He found that cobblestone streets and sidewalk pavements were frequently mentioned, despite being surpassed by more common descriptions of features such as sharp hills, narrow, pitching streets, trees, and handsome old houses. Having Lisbon in mind, a prompt way of judging the memorability of the *calçada* is to track its representation in contexts other than pavements, using them as proxies for its relevance for the image of the city.

From the very start, following the first impact of the artistic pavement in public opinion, the Portuguese pavement made its way into Portuguese literature. Just a couple of examples. Almeida Garrett a nineteenth-century poet, novelist, journalist, and politician, a prominent figure of Portuguese Romanticism, mentioned it in his historic novel *O Arco de Santana* (Santana's Arch) to make a point. He wrote, ironically, that: "No other people in the world can boast of possessing such a rich and vast collection of patriotic hymns; so beautiful all of them, so original, so exciting, that they would make Tyrtæus himself envious (...) and whose words – not to mention all their notes – should be passed to posterity engraved on the buttocks of the sirens of the public boulevard in Lisbon, (...) or – even better – emblazoned by the most beautiful of the beautiful Eusebian arts,<sup>2</sup> on the mosaic of Rossio" (Garrett 1845–50:120–121). Roughly 100 years later, Aquilino Ribeiro, writer and diplomat, unanimously considered one of the greatest Portuguese novelists of the twentieth century, alludes to the image of the sea in the city materialized by the black and white stones of the artistic pavement. In his novel *Lápides Partidas* (Broken Headstones), he wrote: "(...) my attention was drawn to the way that precious Rossio was paved: black and white waves, represented by alternating half-moons of limestone and basalt, rolling over each other in a rhythmic gallop. And I (...) trod this endless mosaic of curves and counter-curves, in order to produce the image, the innocent image, of the high sea" (Ribeiro 1945:16).

Foreign visitors to Lisbon also noticed the *calçada*. Older British travel guides highlight that the Rossio Square was: "(...) known among the English sailors as the Roly-Poly Square, on account of the strange way the pavement is laid. Looks uneven, it looks almost like the waves of the sea, or the ridge and furrow of a ploughed field, and it is quite a surprise in walking across it to find that in reality it is perfectly flat" (Koebel 1909:18; Gonçalves 2015). Rolling Motion Square was also a popular nickname for the Rossio (Johnston 1922).

The *Mar Largo* pavement was particularly noticeable. In 1895, the protagonist of Thomas Mann's (1954) unfinished novel *Confessions of Felix Krull*, Confidence Man reports that: "(...) I finally, then, reached the Rossio with its two bronze fountains, its memorial columns, and its strangely wavy mosaic paving" (Mann 1954:304). Before Mann's confidence man, Hans Christian Andersen — the famous Danish short stories writer — visited the capital of Portugal. During his 1866 stay, he also wrote about the Rossio Square paved 17 years before: "(...) the theatre Maria Secundo [sic], (...) is not large, but is a very handsome building with rows of

columns and statues, opening upon a large square, planted with trees, and with a highly ornamented mosaic pavement" Andersen (1900:246–247).

In literature, as well as in lyrics, it is not always easy to discern between references to plain *calçada*, the pervasive pavement solely using white sett stones, and *calçada portuguesa*, i.e., the artistic pavement. In everyday Portuguese language, one and the other are commonly dubbed *calçada*. When visual elements are involved — paintings, drawings, or photos — it gets easier to tell them apart, as in the cover of the book *Lisbon, the Tagus and the rest*, a literary and photographic project dedicated to Lisbon (Gulbenkian and Mega Ferreira 2017; Fig. 9B). Also in Lisbon's traditional music, the artistic pavement is present, as in the *fado* song *Calçada à Portuguesa* written by Ivan Lins e José Luís Tinoco, and sung by famed Portuguese singer Carlos do Carmo, among others.

These days, the artistic pavement designs are everywhere, replicated using very different media in an astounding variety of contexts well beyond sidewalks and city squares. Portuguese pavement patterns are present in tableware and in fine porcelain items, on postcards, souvenirs, walking guides, sardine cans, furniture, ceramic coasters, building façades, postal stamps, wallpaper, rugs and carpets, children's games, pastry and cakes, grocery store bags, and even on socks and fashionable designer and activewear clothing (Fig. 9B). The *calçada portuguesa*, the urban popular *fado* music (UNESCO heritage), the ceramic tiles, the *liós* limestone monuments (UNESCO global heritage stone resource), local gastronomy, the city hills, etc., all contribute to the image of Portugal's capital. Terribly trendy. Terribly familiar. Terribly commercialized. The Portuguese artistic pavements are more popular now than ever.

### The Artistic Pavements of Lisbon and Sense of Place

Sense of place (SOP) is a complex construct characterizing the relationship between people and their physical surroundings (Frank 2004). It is the summation of the multiple aspects, including local geodiversity, that relate humans to the territory they occupy, be it natural or build (e.g., Gray 2004; Stanley 2004; Kiernan 2015; Silva 2019a). How people perceive the urban environment they live in is, to this day, a major subject of investigation for Environmental Psychology and urban planning researchers alike. Understanding what makes a city memorable is a key concern. In urban settings, as one would expect, architecture and city design, as well as the geodiversity elements incorporated in them, are paramount in the development of a recognizable character of the environment.

In late nineteenth century, the artistic pavement became an important element of the novel approach to city planning, decisively contributing to the re-definition of the image of

<sup>2</sup> 'Eusebian arts' a playful mention to lieutenant general Eusébio Pinheiro Furtado the inventor of the mosaic pavement.

Lisbon. It became central to its new look, i.e., to its imageability. The diversity of artistic pavement patterns and the way they are often used to explicitly communicate with city dwellers — delivering, e.g., commercial, and utilitarian information — play an important role in how individuals read the urban environment (Fig. 3). People use these elements to navigate and to generate a memorable image of a location, which in turn can generate identity and a sense of place (Hull 1992; Russel and Sullivan 2019). According to McCunn and Gifford (2018:217): “The strength of SOP for an urban location and how easily we remember how to navigate appear to be strongly connected.” In turn, as demonstrated by Lynch (1960), how we navigate in the city is linked to its imageability, being paths and landmarks integral to it. Therefore, imageability and SOP are connected, the elements of the build environment that create memorability (e.g., the artistic pavements) being crucial in this process. Moreover, according to Frank (2004), displaced communities tend to utilize architectural features, ornaments, and building materials reminiscent of their roots to create a sense of home away from home. This explains why the significance of the *calçada* transcends its local of origin and how it became a relevant identity urban element in various places around the world, namely where there is (or was) a significant Portuguese cultural presence.

Although Spittles (2015) warned about the dangers of conflation among related terms, the concept of sense of place is related to the Roman notion of *genius loci*, spirit of place. However, whilst in Classical Antiquity each place was thought to own a special character (a *genius loci*) awaiting manifestation, these days SOP is seen as a social construct dependent on human interpretation — both personal and communal — of the local setting. Therefore, again after Frank (2004:590): “(...) for the same location, sense of place will vary from person to person and over time.” This view of SOP is in consonance with the plurality of meanings approach discussed herein earlier. The same heritage asset may be assigned different meanings by diverse groups of people having, however, a common result: the fact that some kind of value is assigned to it. Hence, the communal feeling of place attachment generated by the *calçada* also springs from its capacity of congregating meaning, for very different reasons, in very different groups of people.

## Conclusion

“If a city’s streets look interesting, the city looks interesting; if they look dull, the city looks dull” (Jacobs 1961:29), and sidewalks and their pavements are a fundamental part of streets.

As pointed out by Stanley (2004), geodiversity is the basis for an array of natural and cultural heritage, linking

the Earth, people, and culture. The Portuguese sidewalk pavement emerges from the use of geological elements in urban spaces. It is a superb example of the contribution of geodiversity to ecosystem cultural services (sensu Gray et al. 2013), in particular to the cultural heritage and the built environment, as pointed out, e.g., by Gordon (2012) for Scotland. Created in Lisbon it was later exported to a variety of city settings around the world, from Brazil to Mozambique and Macao (China) where it is often associated to World Heritage sites UNESCO.

There are plenty of examples of outstanding artistic stone sidewalks and pavements all over the world. The Cordovan pavements in Spain, for instance. Also, in Prague and Kutná Hora, Czech Republic, inlaid sidewalks are present. They can be found in Saint-Paul-de-Vence, France, and in Freiburg, Baden-Wuerttemberg, Germany. Also, in Suzhou and Jiading (Shanghai), China, local traditional pavements are known to be exquisite, elegant, atmospheric, and skillful. The Imagine mosaic of Central Park in New York, a paved tribute to John Lennon, is worldwide famous. As with ceramic tiles (e.g., Silva 2019a), artistic pavements are neither a Portuguese invention nor a national exclusive. However, the fact that in Portugal inlaid mosaic sidewalks and pavements are so widespread, so geologically diversified (all over the country), and so artistically prolific, makes them truly remarkable.

The *calçada* is a meaningful, recognizable, and memorable trait of Lisbon, having become crucial for its image, for its memorability, which in turn generates sense of place. And yet, the *calçada* faces perils. Due to high costs, poor maintenance, and lack of skilled craftsmen, its long-term survival may be in danger (e.g., Remesar and Esparza Lozano 2014). To safeguard this geocultural heritage asset for the future, the *calçada portuguesa* was recently included in the Portuguese Intangible Cultural Heritage list a vital first step towards attaining UNESCO intangible world heritage status (Câmara Municipal de Lisboa 2021). However, in the documents formalizing the submission (ACP 2021) and the ratification of its newly attained national status (Diário da República 2021), its geodiversity dimension is largely neglected. To maximize the effect of this conservation effort, the plurality of meanings assigned to the *calçada* by the various groups of people that relate to it, namely its geological meaning, should be involved.

Having in mind the preservation of this major element of Lisbon’s (and Portugal’s) cultural identity, this work focusing the geodiversity of the remarkable *calçada portuguesa*, all the more timely because this year the International Geodiversity Day UNESCO will be celebrated for the first time, hopes to contribute to broaden the scope of the debate beyond its more obvious cultural and touristic (i.e., economical) meanings and values on the path towards attaining World Heritage status.

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## Declarations

**Conflict of Interest** The authors declare no competing interests.

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- Photo and Image Credits** Fig. 2A: Image from the Arquivo Municipal de Lisboa, Câmara Municipal de Lisboa, António Novais (PT/AMLSB/ANV/000412). Fig. 2B: Image from the Coleção do Museu de Lisboa, Câmara Municipal de Lisboa, EGEAC (MC.GRA.1460). Fig. 5B: Image from Paolobon140, Wikimedia Commons at [https://commons.wikimedia.org/wiki/File:La\\_Santa\\_Casa\\_da\\_Misericordia\\_in\\_Largo\\_do\\_Senado\\_Macao.jpg](https://commons.wikimedia.org/wiki/File:La_Santa_Casa_da_Misericordia_in_Largo_do_Senado_Macao.jpg). Fig. 5C: Image from Pedro Angelini, Wikimedia Commons at [https://pt.wikipedia.org/wiki/Ficheiro:Pra%C3%A7a\\_do\\_Teatro\\_Amazonas.jpg](https://pt.wikipedia.org/wiki/Ficheiro:Pra%C3%A7a_do_Teatro_Amazonas.jpg). Fig. 5D: Image from Google Earth. Fig. 8A Image from Zureks, Wikimedia Commons at [https://commons.wikimedia.org/wiki/File:Paving\\_2\\_paving\\_by\\_Zureks.jpg](https://commons.wikimedia.org/wiki/File:Paving_2_paving_by_Zureks.jpg). All remaining photos and images were obtained and/or produced by the authors.
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