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ORIGINAL ARTICLE

Lioz—a Royal Stone in Portugal and a Monumental Stone in Colonial Brazil

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Abstract *Lioz* is a Cretaceous, microcrystalline limestone which occurs in Portugal and outcrops in Lisbon and neighboring counties. The rock color is usually ivory and, less commonly, pink among others. Its fossiliferous content imprints a unique pattern to the rock, contributing to its decorative application. The rock has been used in Portugal as a good quality material for construction for a long period, from the sixteenth century to the present. Along the eighteenth century, its wide use in monuments and official buildings gave it the recognition as the "Royal Stone" in Portugal. Lisbon has the best display of *lioz* as a fundamental stone in several monuments of different ages, official buildings, and many churches. Among the latter, the Jesuit Church of São Roque is a special example, in which interior chapels expose a rich variety of inlays (embutidos), inspired on Italian churches. Not far from Lisbon, Mafra exhibits a monumental architectural set of three integrated constructions built in the eighteenth century by King D. João V using *lioz* limestone. Along the seventeenth and eighteenth centuries, the rock was carried to some Portuguese colonies, mainly as ballast of boats and used at the destinations as construction material. Salvador in Bahia, Brazil is the best example, where *lioz* is beautifully used in monuments and as true art in many churches of Portuguese and Italian influences. These facts make the Portuguese *lioz* as the most representative Heritage stone present in Portugal and its old colonies abroad.

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Introduction

The use of stone as construction material has long been known and its evolution follows, to a certain extent, the path of the evolution of humanity. Wherever the occupation of land by man takes place, there is the necessity to construct shelter, homes, official buildings, churches, and all sort of monuments to register historic facts and occurrences related to society development. Human activities show clearly the close relationship between natural resources and their use as raw materials for constructions in some specific places. The geologic framework of different areas on Earth is associated with constructions since it shapes the availability of materials (in this case, rocks). This circumstance explains the fact that in certain areas of France one finds calcarenite as the main stone material in churches, in Rome a large amount of constructions made of travertine, and the presence of Carrara marble in most churches and sculptures in all Italy. Many examples could be given and this fact is a natural result of having specific rocks occurring at specific places as reflex of the geological history of that area. Portugal is no exception to that and part of its history is "carved" in exposed rocks all over the country.

Corresponding to the diversity of rocks in the whole Portuguese territory, old constructions are mostly of granitic composition in the northern part of the country, while constructions in limestone are more abundant in the central area, marbles have an expressive presence in Alentejo (south of the Tagus River), granitoids and similar rocks along Algarve, and the *lioz* limestone in Lisbon and neighboring areas.

The extensive use of *lioz* in Lisbon has an explanation: during the sixteenth century, the Portuguese maritime activities and

discoveries plus the commercial expansion both in the mainland and overseas stimulated the construction of buildings, fortifications, and churches. The *lioz* limestone, being a natural stone of good properties as a construction material, being nice looking and locally available became the natural source of rock for all those constructions. Lisbon was then a cosmopolitan town, a very active European port where trading merchandises coming from the Orient, Africa, and Brazil was intense. In addition to that, the reconstruction of the city after the 1755 earthquake, when Lisbon was partially destroyed, intensified the rhythm of constructions. The center of the city was rebuilt having that stone as the main building material; several quarries were located nearby and transportation was an easy task. Architects were recruited to design the main official buildings and catholic churches flourished. Today, the use of *lioz* limestone in Lisbon is again very intense, on building façades, on interiors of residences and public places, and as pavement of metro stations, contributing to give luminosity to the city and strengthening its historic position as the main georesource and geoheritage stone, present in almost all monuments of several ages and different architectonic styles.

The scope of this work is to call attention to this unique "lisbonense" rock, identified in the Lisbon area and its vicinity, which was exploited in Lisbon in the past and has been exploited in Sintra for a long time until present day. The path followed by its use, all over Portugal and in old Portuguese Colonies, particularly in Brazil, during centuries, gives the rock a special status and fulfills the requirements established by Cooper et al. (2013) to be considered a Heritage Stone.

Geologic Occurrence

The *lioz* limestone occurs in a Cretaceous (Mid Turonian) Unit described initially by Choffat (1900), identified as a "Crystalline limestone with rudists" (Caprinula d'Orbigny, Sauvagesia sharpei, and others). Limestones occur in a more extensive area of central-western Portugal extending up to Upper Tertiary time having units with different faunas. Zbyszewski (1963) summarizes the stratigraphy of the Cretaceous established by Choffat (1900) based on the study of sequences in the quarries in the Lisbon area as Campolide, Rio Seco, Monsanto, Vale de Alcântara, Belem. The *lioz* horizon overlays a Lower Turonian marly limestone and in turn is overlain by layers of Upper Turonian pink marl, limestone with rudists, and a marly limestone. The fossil content of the microcrystaline *lioz* limestone corresponds to a shallow, clear, and warm water, typical of reef environment. Callapez (2008) refers to the *lioz* as a platform limestone while discussing its occurrence in Alcântara (Lisbon), Negrais, and Pero Pinheiro. Figure 1 is an excerpt of the geological map of Portugal (IGM, 1992) where the *lioz* (limestone with rudists) corresponds to Unit C2, in dark green. Outcrops of the *lioz* limestone are also identified in several localities between Lisbon and Sintra, like Oeiras and Paço d'Arcos, where the rock was used. Quarries were exploited since Roman times. Descriptions of these quarries in Lisbon and their locations are available (Pinto 2005). This helps the understanding of both source and transportation of blocks for the construction of some monuments, as for example the Aguas Livres Acqueduct, (Fig. 2), near Alcântara, where quarries were also exploited. This construction dates from 1713 to 1748 and is one of the oldest constructions of public relevance in Lisbon. Near the aqueduct, the *lioz* limestone outcrops exposing horizontal layers (about 50 cm thickness), as observed in Fig. 3. The location of this outcrop is now recognized as a Geosite, the Geomonument Avenida Calouste Gulbenkian. Another Geosite is also recognized in an old quarry in the neighborhood, the Rio Seco Monument (Lopes 2017). Most quarries in Lisbon are unknown at present; they are either extinguished or hidden by buildings as result of an increase of the urban population. Nowadays, the locality which best testimonies the past and present exploitation of the *lioz* limestone is Pero Pinheiro, where old and actual quarries can be visited (Fig. 4), while blocks of *lioz* are seen enclosed by residences. From Pero Pinheiro, a great volume of rock was extracted in the eighteenth Century to build the Mafra Complex, the large architectonical ensemble of three monumental buildings: Basilica, Library, and Convent, during the reign of D. João V, beautifully described by Gandra (1995, 1998). Martins (1991) reports the occurrence of several varieties of *lioz* in Lameiras and East Pero Pinheiro as the main occurrences of the rock and indicates the total inventory estimated in 13,741,910 tons. These numbers should be higher today as the industry is active in its exploitation.

Petrography, Chemical Composition

The *lioz* limestone has a simple petrography; the macroscopic identification emphasizes the color and the fossil rich texture. The rock can be described as an ivory or light pink color, microcrystalline, bioclastic, fossiliferous limestone. Its fossil content of Rudists, bivalves of Cretaceous age, is a very strong feature of this rock printing its decorative effect. Different colors of the *lioz* limestone are known, being more common the light ivory color, the dark pink variety, known as *Encarnadão* and the *Amarelo Negrais*, a dark yellow type which corresponds to a facies variation of the lioz, containing hydrated iron oxide (limonite). Other colors are identified in old buildings or churches where it was used as a decorative material, in a restricted manner. Light gray and dark purplish red are examples of such use. Figure 5 (a–d) illustrates the macroscopic aspect of the most common varieties: *Lioz*, *Chainnette*, *Encarnadão*, and *Amarelo Negrais*. Calcite makes the totality of minerals in all varieties of the *lioz*

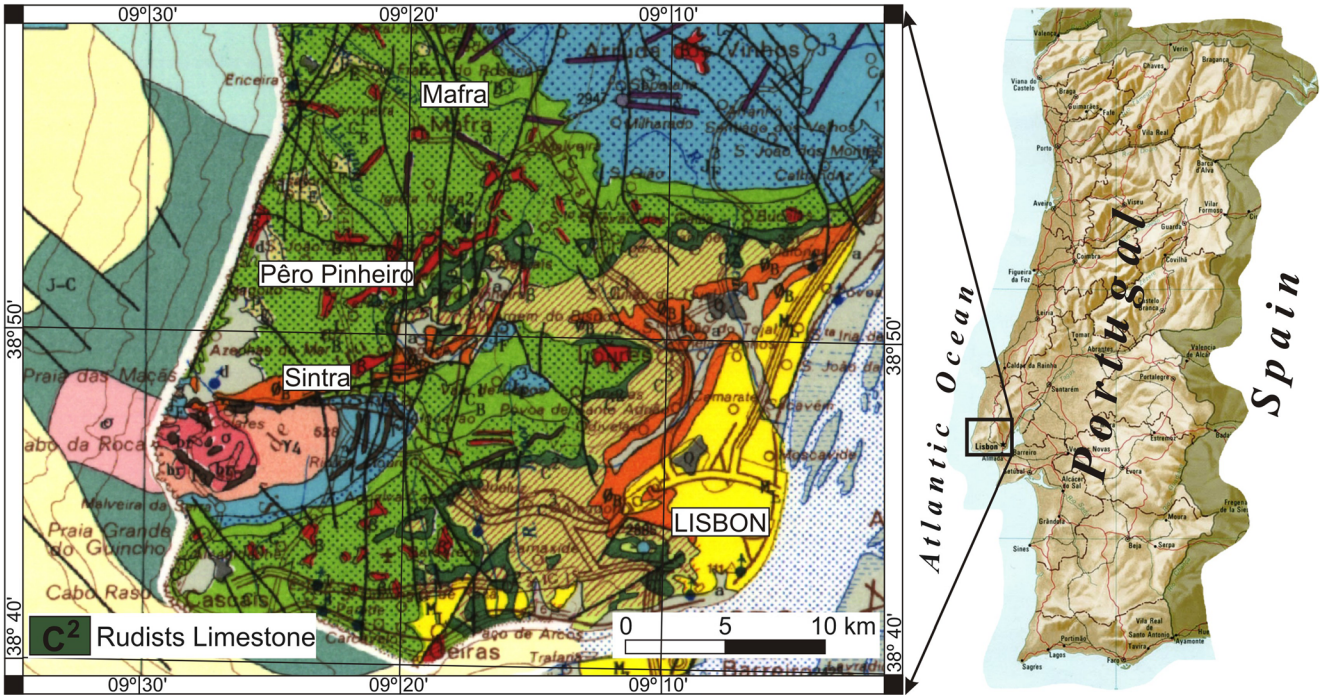

Fig. 1 Excerpt of the Geologic Map of Portugal, 1/500,000 5th Ed., IGM (Geological and Mining Institute), 1992

limestone, except for the *Amarelo Negrais*, where fine dolomite (< 6%) is a minor accessory followed by traces of quartz and iron oxides, as registered by Casal Moura (1992–1996). Under the microscope, they are all biosparite and microsparite.

Chemical analyses for major elements of these four varieties are presented in Table 1. The oxides content is quite uniform due to the almost monomineralic calcitic composition, except for the presence of minor dolomite and iron oxide in the *Amarelo Negrais* sample.

Lioz Limestone as Construction and Decorative Material

Several natural characteristics of the *lioz* limestone, such as the mineral composition, essentially calcite, the microcrystalline texture, and being very compact, made it a good construction material that could be used also for structural purposes. Their shells printing on the rock and the traces of stylolites when the rock is cut across the bedding plane gives a typical pattern and accentuated when the rock gets a polished finishing. Architects make an extensive use of these differences with decorative purposes.

The color variation from light to dark pink (*Encarnadão*) and the two distinct textural patterns of the rock due to the cutting orientation permit a unique decorative use of the *lioz*. In addition to that, the nice yellow color of the *Amarelo Negrais* contrasts very well with the ivory and pink varieties and as such it reached a popular use as decorative elements in churches and palaces on the eighteenth century. Its use today is limited and especially the use in exterior walls is rare due to its high alteration susceptibility.

Fig. 2 Águas Livres Acqueduct, Lisbon

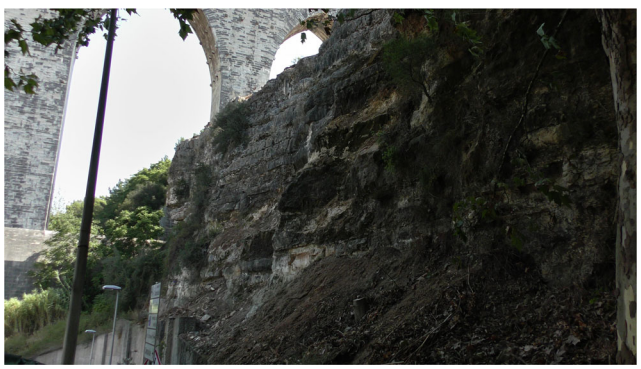

Fig. 3 *Lioz* outcrop aside the Águas Livres Acqueduct, at the Geomonument Av. Calouste Gulbenkian

Fig. 4 Actual quarry of the *lioz limestone*, Pero Pinheiro

The names given to these varieties are associated with local (Pero Pinheiro) nomenclature. The name *lioz* supposedly is an appropriation of a French word *liais* used then to mean special rock or material (Sousa 1897) whose pronunciation is close to *lioz*, in Portuguese. *Chainnette* as an allusion to the aspect the Belgium workers or merchants would refer the appearance of that special cut, across the bedding, as a reminder of "chaine." *Encarnadão* (which means strong red) is a name which has been generalized for the vivid pink, almost red color (encarnado in Portuguese means red). For *Amarelo Negrais*, amarelo is the Portuguese word for yellow, Negrais is the locality where it occurs, near Pero Pinheiro. Other names used in the industry like *Azulino* (Bluish shade, from azul) and *Vidraço* (vitreous, *vidro* appearance) are also known. The light ivory color *lioz* is the most abundant one and more widely used and although the industry has retracted for a long calm period, the recent expansion of constructions in Lisbon and restoration of old monuments activated the exploitation of *lioz* in Sintra region. The need to have old constructions restored and preserved as heritage strengthens the concept of protecting quarries to guarantee a permanent source of *lioz* available for the future, as pointed out by Pereira and Marker (2016). Pero Pinheiro holds the position as the largest available source of that limestone, where recent increased activity has raised some difficulties to local industries sitting on top of the limestone occurrences, causing their move of their installations to other areas.

The different varieties of this limestone despite having small variation in geotechnical properties, still fall into a range adequate to be used in walls, columns, and able to support loading in constructions of buildings and monuments. Some geotechnical properties of the four most used varieties of *lioz* limestone are reported in Table 2. Presently, the DIN, LNEC (Civil Engineering National Laboratory), and NP (Portuguese Norm) Standards have been replaced by the European Norm (EN) for the determination of those parameters.

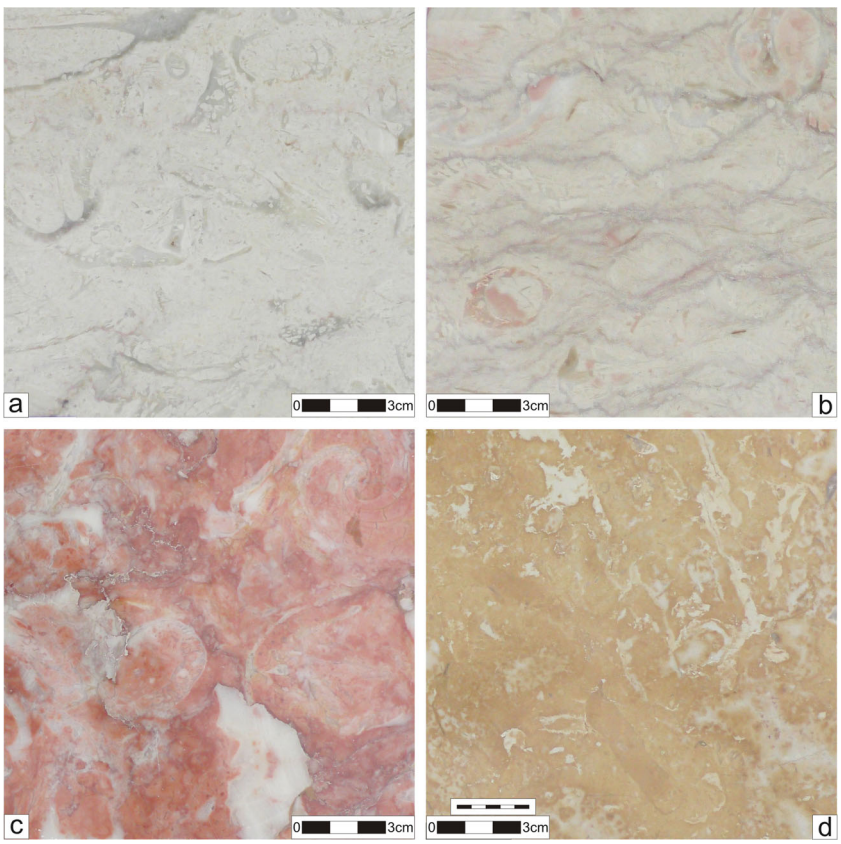

Fig. 5 **a**–**d** Polished plates of the main types of *Lioz* limestone: **a** Lioz; **b** Chainnette; **c** Encarnadão; **d** Amarelo Negrais

Table 1 Chemical analyses of four different varieties of Lioz (after Casal Moura, IGM 1992–1996)

%Oxides (%)	Lioz	Chainnette	Encarnadão	Amarelo Negrais
SiO_2	0.31	0.55	0.35	1.59
Al_2O_3	0.48	0.18	0.25	0.25
Fe_2O_3	0.02	0.05	0.07	0.37
MgO	0.48	0.85	0.36	1.29
CaO	55.49	54.21	55.27	53.02
Na_2O	0.05	0.18	0.06	0.07
K_2O	0.07	0.07	0.04	0.02
L.O.I.	43.35	43.48	43.78	43.22
Total	100.25	99.57	100.18	99.83

The low open porosity values represent a positive characteristic concerning alterability when the rock is exposed to aggressive environment, mainly in places where humidity and atmospheric pollution act together. In monuments near the river, in Lisbon and areas where vehicles circulation was intense, like at the Jeronimos Monastery and Belem Tower vicinity, rock alteration has been visible. Aires-Barros (2000) discusses the problems and suggests methodologies for conservation of the exterior of Belem Tower, some of which were adopted during restoration of Jeronimos Monastery. Car circulations are now better controlled near those monuments. Rodrigues (1992) focus the conservation of stone in Portugal, their problems and methods.

One of the most common alteration features in limestones is the formation of gypsum as black crusts, due to the humidity and the presence of SO_2 in the atmosphere. Yellow crusts are also common after biological colonization. Fissures, lichens, and removal of material around junction of different slabs of rock are common alterations. Lichens and black crusts are some pathologies in which the effect of nanoclimates is notorious, namely in the interior of Jeronimos church where in different sectors of the monument, the alteration of the same rock is different, as discussed by Aires-Barros (2001). By contrast, no special effect was registered on this rock under saline atmosphere, so common in silica-rich rocks in areas with aggressive atmosphere and salt fog exposure near the sea. Some of these remarks are part of observations made by the author, while following alteration on silicate and calcareous rocks in different environments, along the coast and along the Tagus River in Lisbon and in the laboratory. Silva and Simão (2009) compared the alteration susceptibility of silicate and calcareous rocks to salt fog and registered the strong relationship between open porosity and weight loss in carbonate rocks. Within the *lioz* varieties, the highest loss is found in *Amarelo Negrais* (open porosity 1.18%), contrasted to the *Chainnette* (open porosity 0.17%). Rock finishing or surface treatment also influences the rock alteration susceptibility and its rate of alteration (Silva et al. 2013). When polished, honed, and hammered finishing are compared, the first type is more resistant to alteration and the last one more susceptible to it (Silva and Cruz 2013). Although not experienced in the laboratory, the visual observation on monuments, walls, and pavements is in full agreement with the results obtained on laboratory experiments on silicate rocks. *Lioz* limestone is also studied by Figueiredo (1997) while discussing technological aspects of calcareous rocks from Lisbon region.

The Use of Lioz in Portugal. History and Architecture Links

Lioz limestone was so appreciated by constructors, architects, and Portuguese authorities that its use was widespread in the country for a long time in official buildings and churches in different localities. This stone was taken in many instances by marble, possibly due to its beauty and special appearance when getting a polished finishing. The stone was used since the construction of the São Jorge Castle in Lisbon, where raw blocks can be found today among other rocks, limestone or

Table 2 Geotechnical properties of the four most common varieties of *Lioz* limestone*: Lioz, Chainnette, Encarnadão, Amarelo Negrais* (After Casal Moura, IGM 1992–1996)

Geotechnical properties	Lioz (Lameiras)	Chainnette (Lameiras)	Encarnadão (Lameiras)	Amarelo Negrais (Negrais)	Standard
Compressive strength kg/cm^2	900	1296	937	1442	DIN 52105
Bending strength kg/cm^2	185	221	198	203	DIN 52112
Apparent volumic mass kg/m^3	2695	2708	2701	2674	DIN 52103
Water absorption at atmospheric pressure (%)	0.16	0.07	0.10	0.44	DIN 52103
Open porosity (%)	0.42	0.17	0.28	1.18	LNEC E-216-1968
Abrasion test (mm)	2.3	1.8	2.6	2.8	NP 309

Fig. 6 Mafra Monument, Basílica, Monastery, and Library

not, mostly having a nearby provenance. The presence of lioz in the castle can be traced from that time (Medieval time) until today, in recent restoration works. In central Portugal, in Tomar, the Convent of Christ, built from the twelve to the eighteenth centuries, also carries *lioz*. The Complex exhibits architecture styles from Romanic, Gothic, Manueline, to Renaissance and Mannerism, leaving behind testimonies of many artistic influences which flourished in Europe in that period. The monument is built essentially in regional limestone, but *lioz* is also present in specific parts of it. The round church, with polygonal interior "charola," preserves the Romanic style. Different limestones can be identified there, used as raw material, and carries some decorative features sculptured in *lioz*. In this monument rests one of the most famous constructions on Manueline style, the window of the Chapter House. *Lioz* is present there as it is in several pavements in the Convent as in the D. João III Cloister, featuring the Mannerism style, the last stage of Gothic style, corresponding to late fifteenth century.

During the sixteenth and seventeenth centuries, the Jesuits had a great influence on the architecture of churches both in Portugal and abroad, and the dissemination of the Mannerism style was strong, as emphasized by Almeida (1976). Many churches were influenced by the Jesuit churches, although it would not be proper to call it an Architectonic Jesuit style. Jesuit churches promoted simplicity and a functional interior space. This principle was later carried to Brazil during the religious expansion and consequent construction of many religious temples, even for religious Orders other than the Jesuit and the *lioz* limestone was always present. In Portugal, *lioz* was the privileged construction material used in Lisbon but also in some other parts of the country. In Santarém, Central Portugal (Ribatejo), where Gothic style was prominent, the Cathedral was constructed in Mannerism style (seventeenth century), having in its façade a strong Flemish influence. In the interior, the Baroque style is dominant. Today, *lioz* prevails also in the neighboring area of that Cathedral, including the pavements of the streets around the monument. In Évora,

Fig. 7 Detail of Jerónimos Monastery Interior

Fig. 8 Detail of inlays in a chapel at São Roque Church

Alentejo, the Espírito Santo church (1572), Jesuit, Mannerism in style displays a good variety of *lioz* as inlays used for decorative purposes; in the same town, Évora, the Cathedral although built in granite, in combined styles such as Romanic, Gothic, Manuelino, and Baroque, exhibits a nice exposure of *lioz* in the Main Altar, where inlays are also displayed. At Mafra, not far from Lisbon, the Baroque Mafra Monument (Fig. 6) is a *lioz* vitrine where all varieties of the stone were used, displaying small pieces of rock in many colors in the decoration of altars, pavements, and chapels as inlays (embutidos), as well as large blocks, these ones transported in very difficult conditions from Pero Pinheiro, as described by Saramago (1982). According to Gandra (1998), each little piece of rock had a meaning on the Convent and church. The *lioz* limestone was then considered "The Royal Stone" and Mafra Complex the emblematic symbol of D. João V reign in Portugal. Lisbon, the places of greatest presence of the *lioz* are as follows: The National Parliament, the Rossio Railway Station, the National Theater, the Pantheon, the Ajuda Palace, and a great number of Catholic churches, several of them built in downtown Lisbon; other examples are the São Vicente de Fora Church, the Main altar at Jeronimos Monastery, and São Roque Jesuit church, all Mannerism. In the interior of Jeronimos Monastery (Fig. 7), the Manueline style features decorative elements related to the sea and navigation, like knotted ropes, plus the armillary sphere and the cross of Christ, all inspired in the discoveries of Vasco da Gama and Pedro Álvares Cabral. São Roque Church carries a delicate combination of varieties of *lioz* as inlays in most chapels, emphasizing the strong Italian influence. The interior of this church is very rich in decoration (Fig. 8) contrasting with the rather simple façade, a good representative of the Jesuits churches built in the sixteenth century. São Roque Church was inspired in the Church of Gesu, in Rome, the main house of Saint Ignacio de Loyola, the founder of the Jesuit Religious Order.

The privileged place to illustrate the relationship of the rock to Portugal history and architecture is the historic area of Belem, in Lisbon, where monuments recording different moments of history are located, reminding the departure of navigators to explore the new world in the fifteenth century (Belem Tower); celebrating the Portuguese discoveries (Jeronimos Monastery, late fifteenth to sixteenth centuries); the monument Padrão dos Descobrimentos (Monument to the discoveries), offered to Portugal by Brazil and South Africa (early twentieth century), to celebrate the Portuguese navigators and the Cultural Center of Belem (CCB), built in late twentieth century to host the European Community Capital. All these monuments are built in *lioz*, featuring different styles, celebrating several moments of Portugal history in a very harmonious way. Figures 9, 10, and 11 illustrate these monuments and the area where they are built. The rock finishing of the latter features a new and unusual design that was specially conceived for that monument.

Fig. 9 Belem Tower, Lisbon

Fig. 10 Jeronimos Monastery, Lisbon

Lioz as Ballast in Vessels, Portugal Expansion, Colonies

The maritime expeditions performed by Portuguese navigators during the last decade of the fifteenth to the sixteenth centuries, featuring the discovery of new maritime routes to the Orient and finding new lands in Africa and to the Occident, Brazil, enlarged the volume of goods to be exchanged and inaugurated a very intense trade through the seas that motivated the construction of vessels and equipment. The official *discovery* of Brazil was a special moment for Portugal (1500) and after the recognition of the new land, its division in smaller territories to develop agriculture and explore mineral resources (sixteenth to seventeenth centuries), required transportation of people and goods to and from the new places. Several expeditions took place from Portugal to Brazil, sometimes making connections to India. Places were chosen to build safe harbors which came to coincide with the foundation of many cities. Most of them became capitals of those territories (capitanias). Ports like Belem in northern Brazil, followed southwards by Recife, Bahia, and Rio de Janeiro became important trade cities and centers for local political decision making. There is strong presence of official buildings constructed with *lioz* limestone during colonial time in those cities, also recorded by Costa (2009), but the best examples of that usage are shown in catholic churches, starting with the Jesuits when they first arrived in Bahia (1549) with the first governor of Brazil. The volume of *lioz* carried to Brazil was also increased. Blocks of *lioz* were at that time transported on the vessels serving as ballast in the way to Brazil to stabilize them, being unloaded at their final destinations and then used in the construction of official buildings and many churches. References of the arrival of these blocks of stone or mounted pieces for decoration are reported by IPAC (1997), with special reference to the stone masonry for Conceição da Praia Church, "arriving as ballasts in vessels, in 1739." Some churches were built in response to social disputes within the affluent society at that time, some having the intention to maintain their "*Portuguesehood*" in the new land.

Fig. 11 Monument to the Discoveries, Belem Cultural Center (to the left) and Marinha Museum, back

Promoters of the constructions would select well-known architects, designers, artists, and master of works for that job (Silva 2007) and in general those churches were copies of Portuguese ones, having in many cases a strong Italian or Spanish influence. Bahia, given the circumstance of being the first capital of Brazil, got the most important contribution, a fact that can be traced today. Names like Frei Macário de São João, Benedictin of Spanish origin, bringing influence of the Turrianos, also from Spain, the architects of King Filipe II from Spain, at the time Portugal was under the Spanish domain. Before the Turrianos, Felipe Terzi, who worked with Vignola, in Italy, also worked for Felipe II, leaving testimony of his influence in Portugal and in Bahia on the seventeenth century. Frederico Ludovice (Ludvig), a German designer who worked for D. João V as an architect, influenced the religious art in Bahia and had one of his followers, Manuel Cardoso de Saldanha, Portuguese, as the architect of the N.S. Conceição da Praia church (Ott 1989). The artistic "touch" of those architects is recognized in the colonial cities in Brazil where all monuments and churches were built in the *lioz* limestone. In this way, *lioz* represents the best relict of European architecture in Portuguese Brazil. Conceição da Praia church was totally carried pre-cast from Portugal in *lioz* and assembled in situ (IPAC 1997). Some specific features are recognized at the entrance of this one and other contemporaneous churches, the "Compass Rose" inlays, as a mark of the special moment Portugal was going through, discovering the world (Figs. 12 and 13). Other artistic exposures of *lioz* as inlays are seen on pavements of chapels (Fig. 14) or Sacristies on several other churches where decorative patterns in *lioz* are prominent (Figs. 15 and 16).

Lioz as Baroque Art in Churches of Brazil—Bahia as Case Study

Construction of monuments and churches in Bahia during the eighteenth century was so intense that the area where the cathedral is located (Jesus Square) seemed to be a large construction

Fig. 13 *Lioz* inlay, S. Domingos Church

site. At a time, five different churches, belonging to different religious orders, were being built, two of them in *lioz*: the Cathedral, Jesuit and S. Domingos Church, Benedictin. In a more modest church, S.Pedro dos Clérigos, whose construction lasted from the eighteenth to the nineteenth century, *lioz* was used only in the interior of the church, mainly as inlays in pavements, as a decorative material. The other two churches located in the Jesus Square are Franciscan. They have their façades in local sandstone: Third Order of S. Francisco and S. Francisco Church and Convent. The former one exhibits a beautiful façade in Spanish Plateresc Style. Inside, plenty of *lioz* was used and in the Sacristy stands a very artistic lavabo with *lioz* inlays (Fig. 17). The neighbor São Francisco Church exhibits one of the most representative Baroque art in Brazil. Its cloister is built in *lioz* and the main Altar pavement exhibits a notable work of inlays in *lioz* (Fig. 18). In front of this church, a huge Cross made in *lioz*, together with the S. Francisco Convent and Church make one of the most beautiful religious architectonic assemblage in Bahia, representative of the arrival of the first Franciscan priests in Brazil, in 1587. Many other examples could be listed, featuring historic moments of Portugal and Brazil which influenced the construction of monuments and churches transferring "fashion" and styles from Europe to

Fig. 12 *Lioz i*nlay, N.S. Conceição da Praia Church

Fig. 14 *Lioz* inlay, N.S. Conceição da Praia Church, pavement

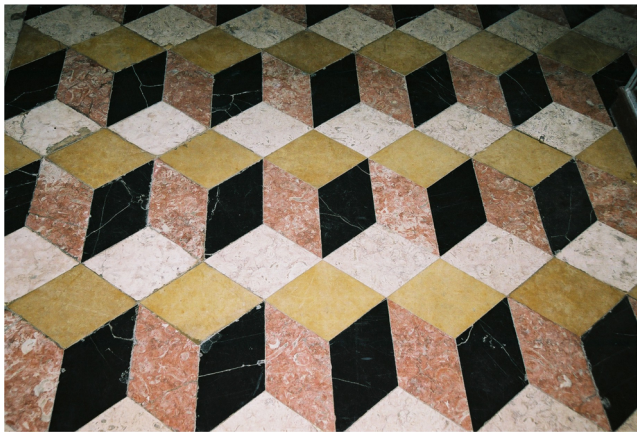

Fig. 15 Pavement of Sacristy, N.S. Carmo Church

Brazil. Some aspects of *lioz* uses and their cultural meaning were discussed by Silva 2017) at EGU 2017.

After a few years of research on churches and monuments in which *lioz* limestone was the main construction material, recognized as vehicle of culture and art between Portugal and Brazil, Silva (2007) summarized:

"In this way, the Portuguese *lioz* had its life cycle defined, carrying an enormous cultural burden from Europe to Brazil. Starting on Cretaceous Portuguese seas around 120 million years ago, it left the quarries from Pero Pinheiro, Lameiras, Morlena, Terrugem and Negrais, crossed the Atlantic Ocean as vessels ballasts and berthed in Salvador where it became art in Convents and Churches of Bahia".

Conclusions

The traditional use of stone in constructions in Portugal is well defined in the whole country where different regions used their local and available material as building stones. However, the use of *lioz* limestone reached a status of national preference for the construction of official buildings and monuments in such a way that during the eighteenth century it was

Fig. 16 Central medallion in the pavement at Sacristy, Cathedral

Fig. 17 *Lioz* inlay at the base of a lavabo at Ordem Terceira S. Francisco in Bahia, Brazil

considered the *Royal Stone*. Its occurrence and availability, together with its mineral composition (calcite) and easy handling by the masons made its use desirable in buildings requiring quality, both technical and artistic. Its fossiliferous content gave the rock beauty turning it into a unique decorative stone as it was also available in different colors. Pero Pinheiro, the main occurrence of that rock, is until today the largest producer where several industries are installed and promote the rock exploitation. *Lioz* was transported in large scale in vessels serving as ballast in the westward journey during the long period of colonial exploration, to Brazil. At that time, religion was also in expansion in the new world and both countries, Portugal and Brazil, were prosperous, and the need to build churches and monuments plus the erection of official buildings increased the use of *lioz*. It became also known as the Monumental stone due its large use in those constructions. Many cities, important development nuclei during the construction of Brazil, keep the memory of these old periods of Brazil's history printed in their historical places in *lioz* limestone. In Bahia today (Salvador, its capital), possibly the place

Fig. 18 *Lioz* inlay at the main altar pavement at São Francisco church in Bahia, Brazil

where most of this memory is alive, it is still possible to trace the influence of Portugal in the local architecture through old constructions, mainly churches, where the influence of Italian and Spanish arts is also strong. All these facts contribute to make the *lioz* limestone a proper and legitimate candidate to be nominated as a Global Geoheritage Stone.

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