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# IUGS Heritage Stone Subcommission


AERIAL VIEW OF THE HISTORIC “JASPER”QUARRY
IN ÁRRABIDA TECTONIC CHAIN, NATURAL PARK SINCE 1976

## HERITAGE STONE

## BRECHA DA ARRÁBIDA

PORTUGAL

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# *"ONE OF THE MOST EMBLEMATIC PORTUGUESE ORNAMENTAL STONES EXPLOITED SINCE THE ROMAN PERIOD"*

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- Formal name: "Brecha da Arrábida" (Arrábida Breccia);
- Stratigraphic (or geological) name: The "Brecha da Arrábida" is an informal unit of the Upper Jurassic, at the base of the "Marls, clays, limestone with black pebbles and conglomerates of Arrábida Formation" (1:50.000 Geological Map 38-B, Setúbal, IGM, 1994).
- Other names: Pedra do Jaspe (Jasper Stone); Vermelho antigo (Ancient Red); Grés vermelho (Red Sandstone), Conglomerado d'Arrábida (Arrábida Conglomerate), Mármore mosaico da Arrábida (Arrábida Mosaic Marble), Mármore da Arrábida (Arrábida Marble), Brechas de Portugal (Portugal's Breccia).
- Commercial name: Brecha da Arrábida

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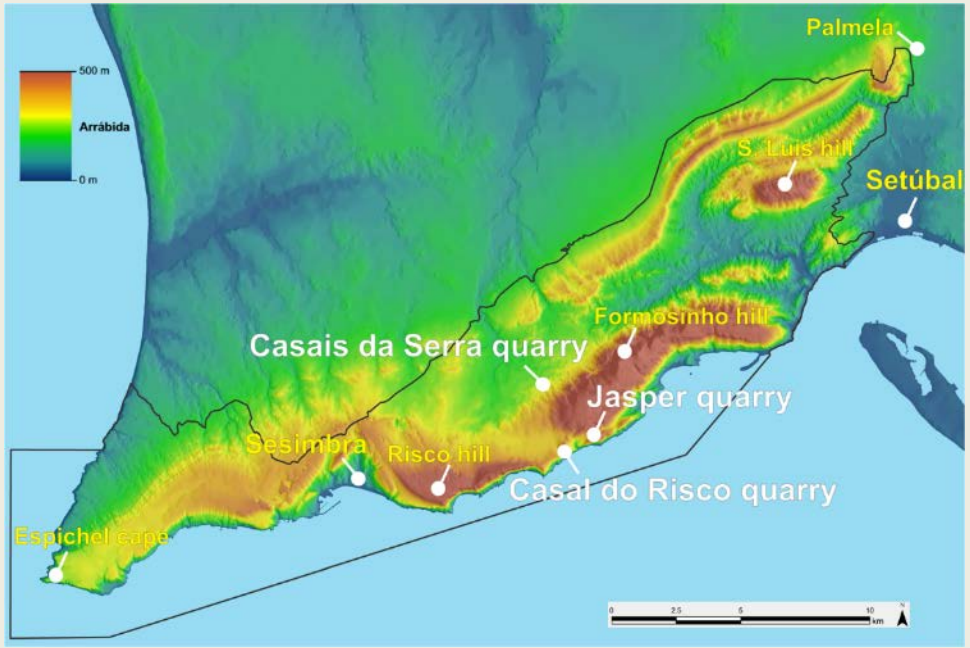
# Geographic Location


Brecha da Arrábida active quarries in the second half of the twentieth century (white text) and limit of the Arrábida Natural Park, created in 1976 (black line).



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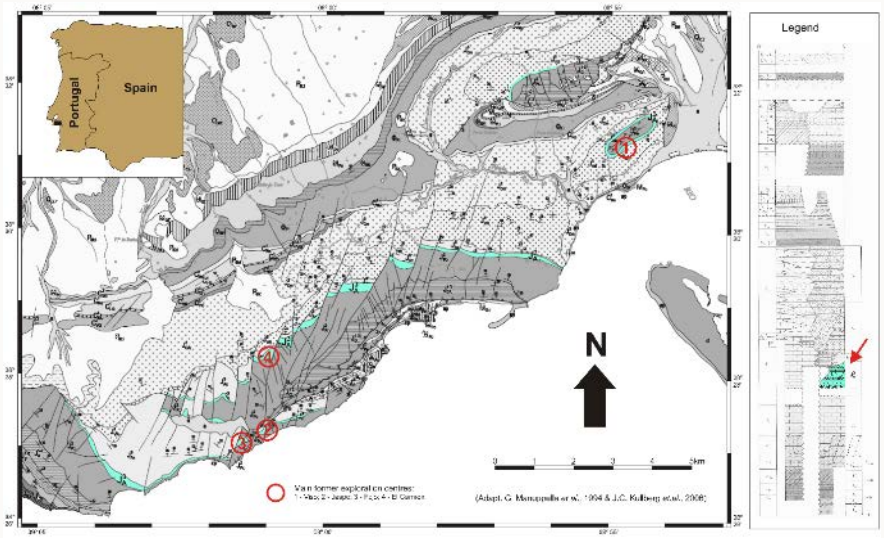
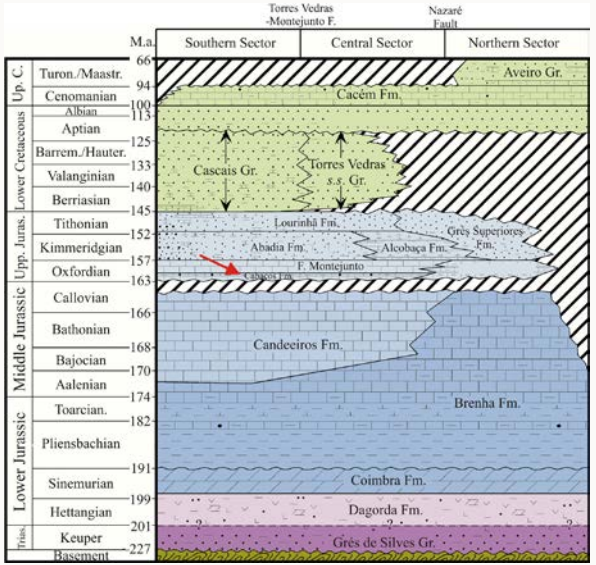
# Geological Context




- Intraformational conglomerate breccia, of granular support, with carbonate clasts of different colours, in a carbonate-red clay cement;
- Associated to Upper Jurassic (Middle to Upper Oxfordian) immersed karst.

# Geological Context

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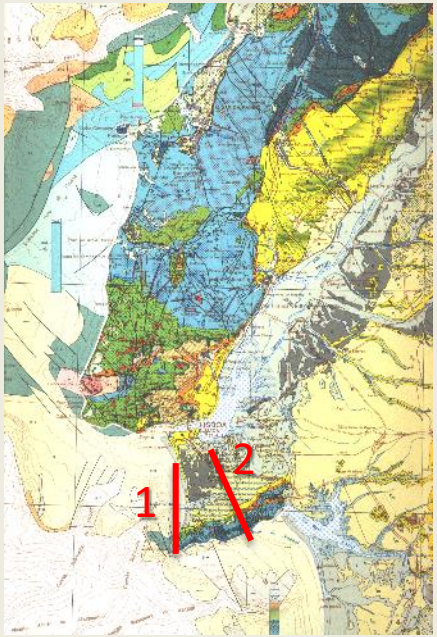


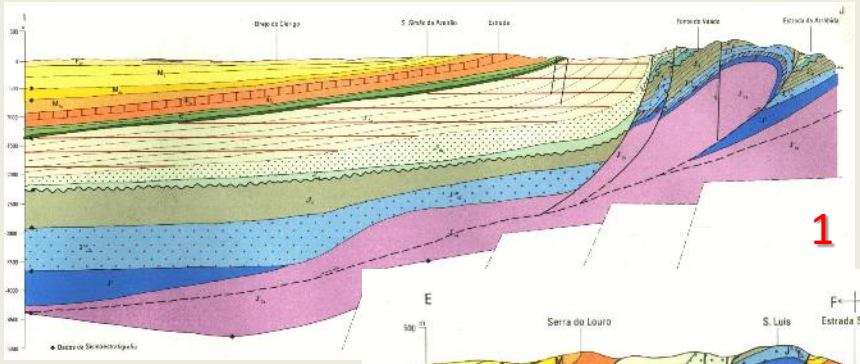


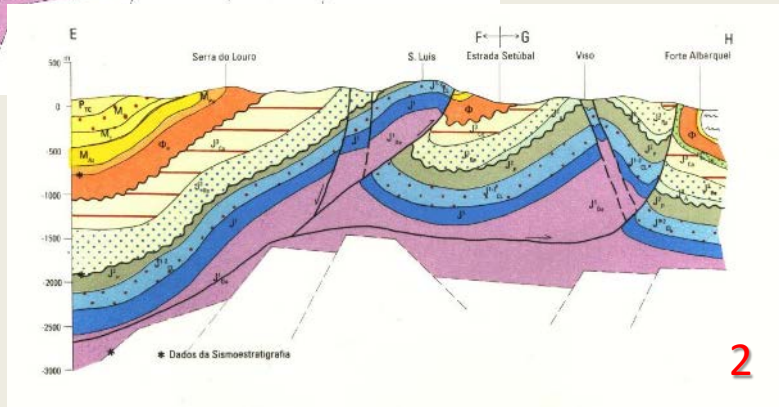

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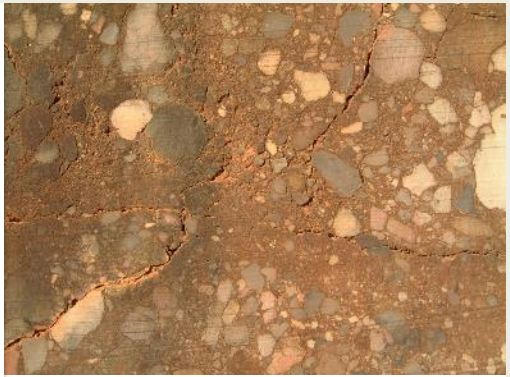


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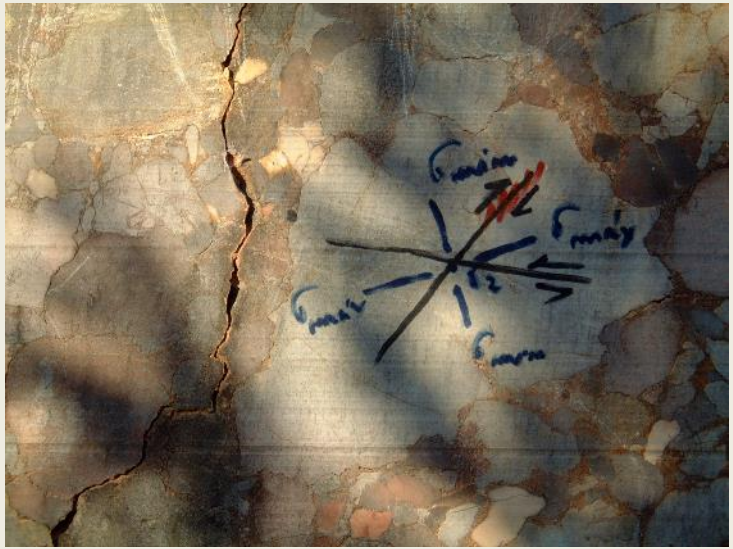

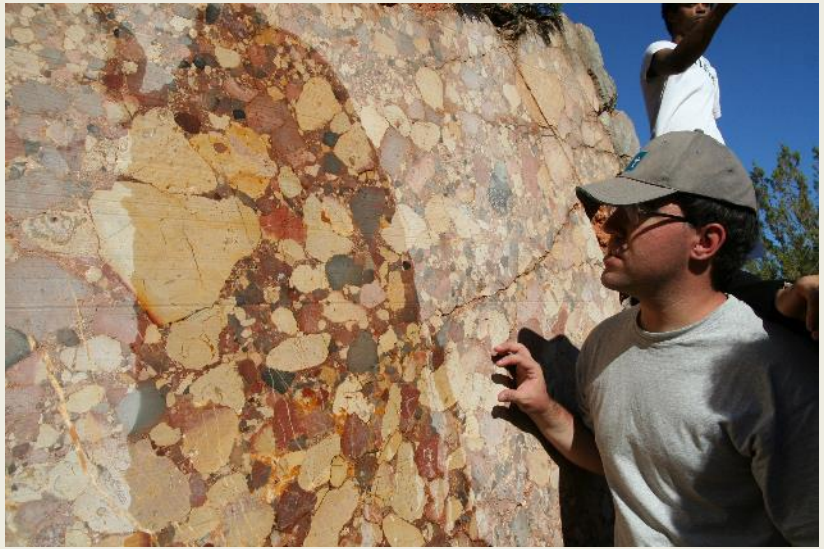

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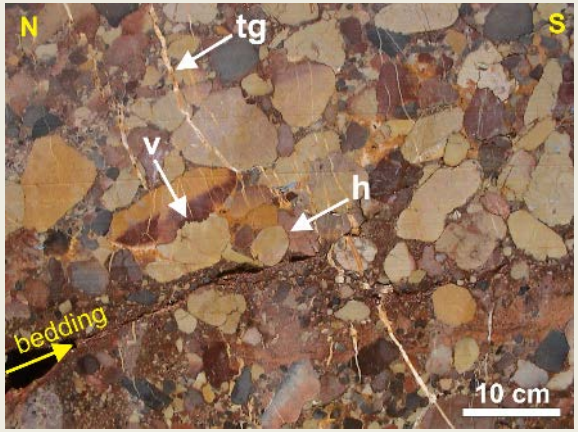


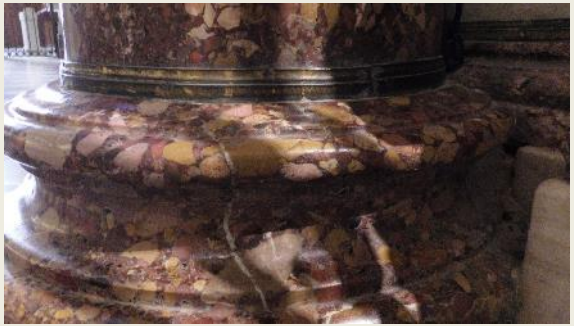

Deformation structures and bedding in a cut wall of “Jasper Quarry”, oriented approximately N-S.

**V arrow** point to vertical (perpendicular to bedding) stylolites related to the diagenetic compression (very intense indentation in the clasts pointed by the “V” arrow.

**h arrow** point to horizontal (bed parallel) stylolites form by tectonic compression between Africa and Iberia during the Lower-Middle Miocene; all the outcrop is tilted to the North since it is located in the Northern limb of the fold related to the southernmost overthrust, responsible by the formation of the Arrábida Chain.

**tg arrow** is pointing to a set of tension gashes, sub-vertical, parallel to the diagenetic stylolites.

Same structures are found in the Toledo Cathedral, Spain.

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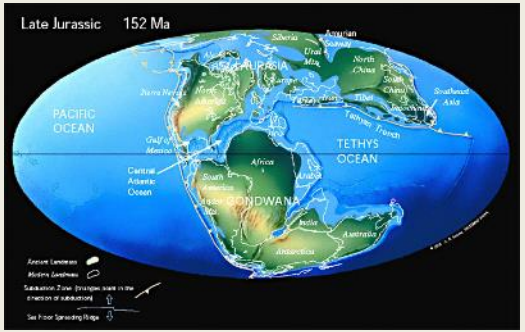
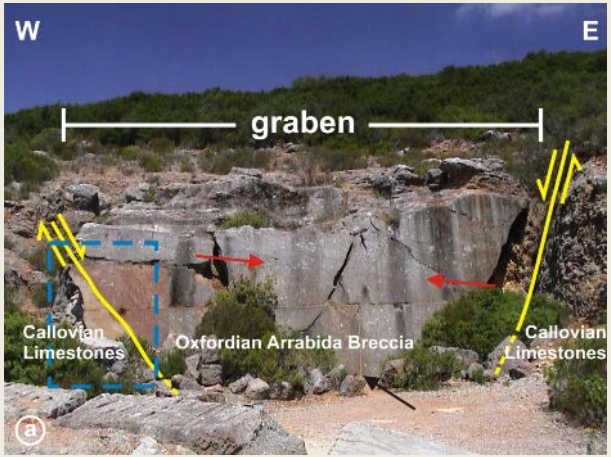
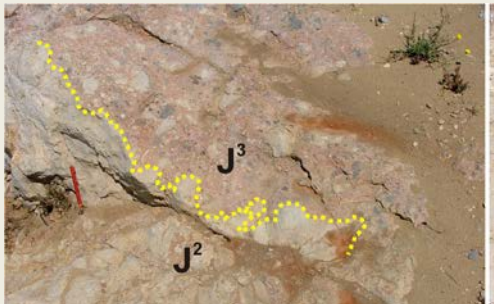
It marks a basin wide unconformity related to regional emersion processes during one of the first episodes of the North Atlantic opening (pré-oceanization rifting episodes); the facies correspond to the infilling of paleokarst surfaces.

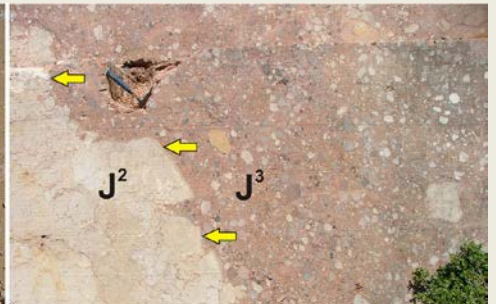



http://scotese.com/late1.htm







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Layering of the “Brecha da Arrábida”, at a macro-mesoscale.




a ) “Jasper Quarry” layering of clasts (yellow bar for scale – 1 m);
b) Tabletop in the Ajuda Palace (Lisbon);
c) Tabletop in the Wallace Collection, London, United Kingdom.

Twisted columns in a chapel inside the S. Joseph (S. José in Portuguese) Church, Lisbon; side-by-side showing very distinctive aspects, both from color and grain size and support

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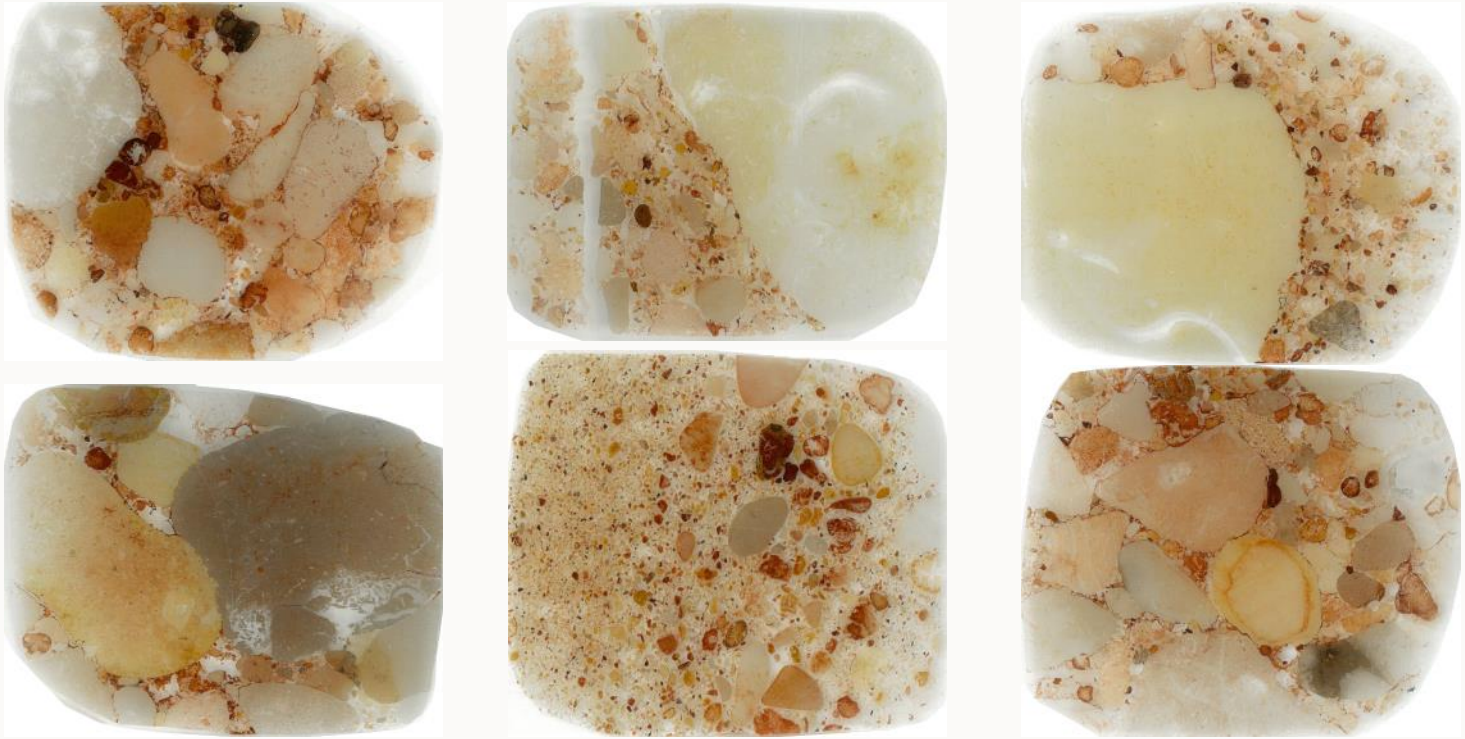

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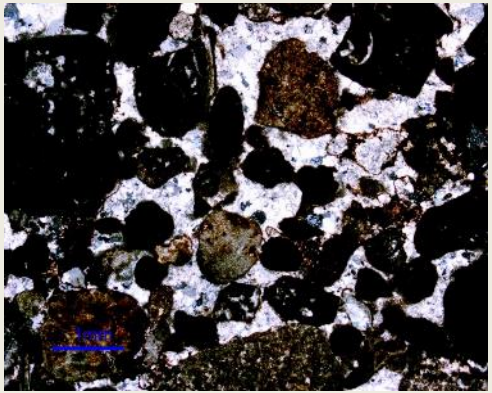
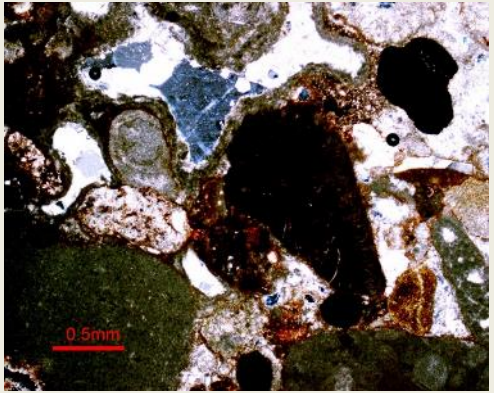
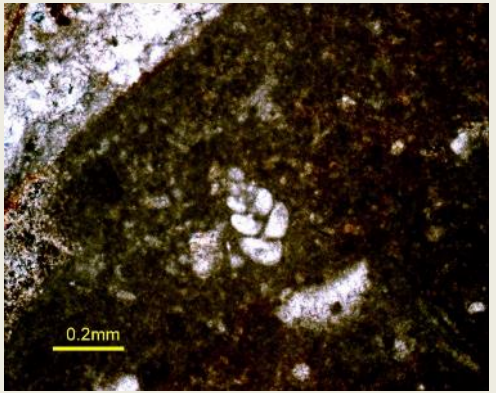


Micritic rudites, with iron oxides and carbonated sandstone with some quartz grains. Sparry cement.




Matrix with micritic and sparry debris, iron oxides and also clay. Sparry and micritic cement.




Callovian limestone with a section of a foraminifer.

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# Summary of Brecha da Arrábida geotechnical properties.

| TEST CATEGORY | INITIAL TYPE TEST | | MEAN VALUE | | |
|---|---|---|---|---|---|
| Identification Tests | NP EN 13755:2008 - Determination of Water Absorption at Atmospheric Pressure (%) | | 1,10 | | |
| | NP EN 1936:2008 - Determination of Apparent Density (kg/cm$^3$) and Open Porosity (%) | | Apparent Density | | Open Porosity |
| | | | 2651,28 | | 2,31 |
| | NP EN 1925:2000 - Determination of Water Absorption by Capillarity (only performed if the rocks Open Porosity is > 1%) (g/cm$^2$s$^{0,5}$) | | 1,789 | | |
| | NP EN 1926:2008 - Determination of Uniaxial Compressive Strength (kg/cm$^2$) | | 103,09 | | |
| Work Performance Tests | NP EN 14158:2005 - Determination of Resistance to Impact (m) and Determination of the Rupture Energy (J) | | Rupture Height | | Energy Rupture |
| | | | 0,43 | | 4 |
| | NP EN 14231:2006 - Determination of the slip resistance by means of the British pendulum tester (SRV) | | Dry Conditions | | Wet Conditions |
| | | | 43 | | 18 |
| | NP EN 13364:2006 – Determination of Rupture Load at Anchor Hole Level (N) | | 1691 | | |
| Durability Tests | NP EN 14157:2007 - Determination of the Abrasion Resistance using the "Capon" Method (mm) | | 20,50 | | |
| | NP EN 14066:2014 - Determination of resistance to ageing by thermal shock | Samples submitted to 20 cycles of thermal shock | Before the Cycles | After the Cycles | Variation (%) |
| | | NP EN 1936:2008 Open Porosity (%) | 1,58 | 1,80 | +13,94 |
| | | NP EN 14146:2006 - Determination of the Dynamic Elasticity Modulus | 58587 | 58114 | - 0,78 |
| | | NP EN 14579:2007 - Determination of the Sound Speed Propagation (km/s) | 5,50 | 5,33 | - 3,01 |
| | | NP EN 12372:2008 - Determination of Flexural strength under centric load (MPa) | 11,23 | 10,77 | - 4,10 |
| | NP EN 12371:2015 - Determination of resistance to ageing by Ice-Defrost cycles | Samples submitted to 20 cycles of thermal shock | Before the Cycles | After the Cycles | Variation (%) |
| | | NP EN 1936:2008 Open Porosity (%) | 1,58 | 2,64 | + 70,32 |
| | | NP EN 14146:2006 - Determination of the Dynamic Elasticity Modulus | 58587 | 54011 | - 7,55 |
| | | NP EN 14579:2007 - Determination of the Sound Speed Propagation (km/s) | 5,50 | 5,05 | - 8,01 |
| | | NP EN 12372:2008 - Determination of Flexural strength under centric load (MPa) | 11,23 | 10,30 | - 8,28 |

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## History and social impact

The first reference know to the “Brecha da Arrábida”, not with scientific purposes was made by Duarte Nunes Leão (1530-1608): *”From this stone is built all that great village (the city of Setúbal), with houses, temples, walls and towers, because there is no other stone like this, so in the village and its terminus, as in the mountains, neighbouring the Arrábida mountain range, [...]. Therefore, all buildings must be hers…”* (Galopim de Carvalho, https://www.facebook.com/groups/619922464786873/posts/4544172052361875/

The first scientific reference to Brecha da Arrábida comes from the **Baron of Eschwege (1831)**, when studying the region of Setúbal, designates a type of rock as “Ancient sandstone", also indicating the corresponding formations in Germany, France and England, respectively: “Rothe-todliegende”, “grés houiller” and “Grés rouge”. He describes the location of the outcrops, stating that: “*appears at the foot of Setubal, at the foot of the Serra de S. Luiz and Palmella, on the south coast of Serra da Arrábida*” and even though “*this ancient sandstone seems to form the base of all the most modern formations near the Serra da Arrabida, which is still need to check*” (ESCHWEGE, 1831, p. 269)

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# History and social impact

In 1841, Daniel Sharpe, an English geologist who came to Portugal in 1831, publishes in the **Transactions of the Geological Society of London** a memoir entitled: *"On the geology in the neighbourhood of Lisbon*". It is in the description of the geological units of Lisbon and, in addition to the numerous profiles that illustrate the geology from Alenquer to Setúbal, the first map of the surroundings of Lisbon. Daniel Sharpe (1806 – 1856) has a remarkable knowledge of the stratigraphy of Portugal. His works on the outskirts of the cities of Lisbon and Porto are precursors of Portuguese paleontology and the first national geological maps at 1:500.000 scale (1867, 1876 and 1899).

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Geological map “The Neighborhood of Lisbon” (SHARPE, 1841)

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# Heritage utilisation

Built at the beginning of the first century AC, the oldest evidence of the use of the “Brecha da Arrábida” dates to the Roman presence in the Setúbal region, formerly Cetóbriga, confirmed by two archaeological records: the archaeological site of Tróia and the Roman stonepaved way of Viso.

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# Synthesis of occurrences of the Brecha da Arrábida in Monuments

In Portugal, from the **88 occurrences** listed (on work list), 65 are applications in classified Monuments, 24 of which are National Monuments, and some integrated in UNESCO classifications.

Several historical applications can be listed in Monuments in six foreign countries: Austria, Brazil, France, Mozambique, Spain and United Kingdom.

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# Synthesis of occurrences of the Brecha da Arrábida in Monuments

One of the most emblematic monuments is the Jesus Church and Convent (Setúbal), distinguished by the European Commission with the “European Heritage Label” (2011), in 2013 was recognized by the Pan-European Federation of Cultural Heritage Europa Nostra” as one of the seven most endangered monuments in Europe (https://7mostendangered.eu/sites/manueline-style-monastery-and-church-of-jesus-in-setubal-portugal/).

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# Synthesis of occurrences of the Brecha da Arrábida in Monuments


Maputo Railway Station, Mozambique

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