# Natural and artificial weathering on stone materials

Fabio Sitzia

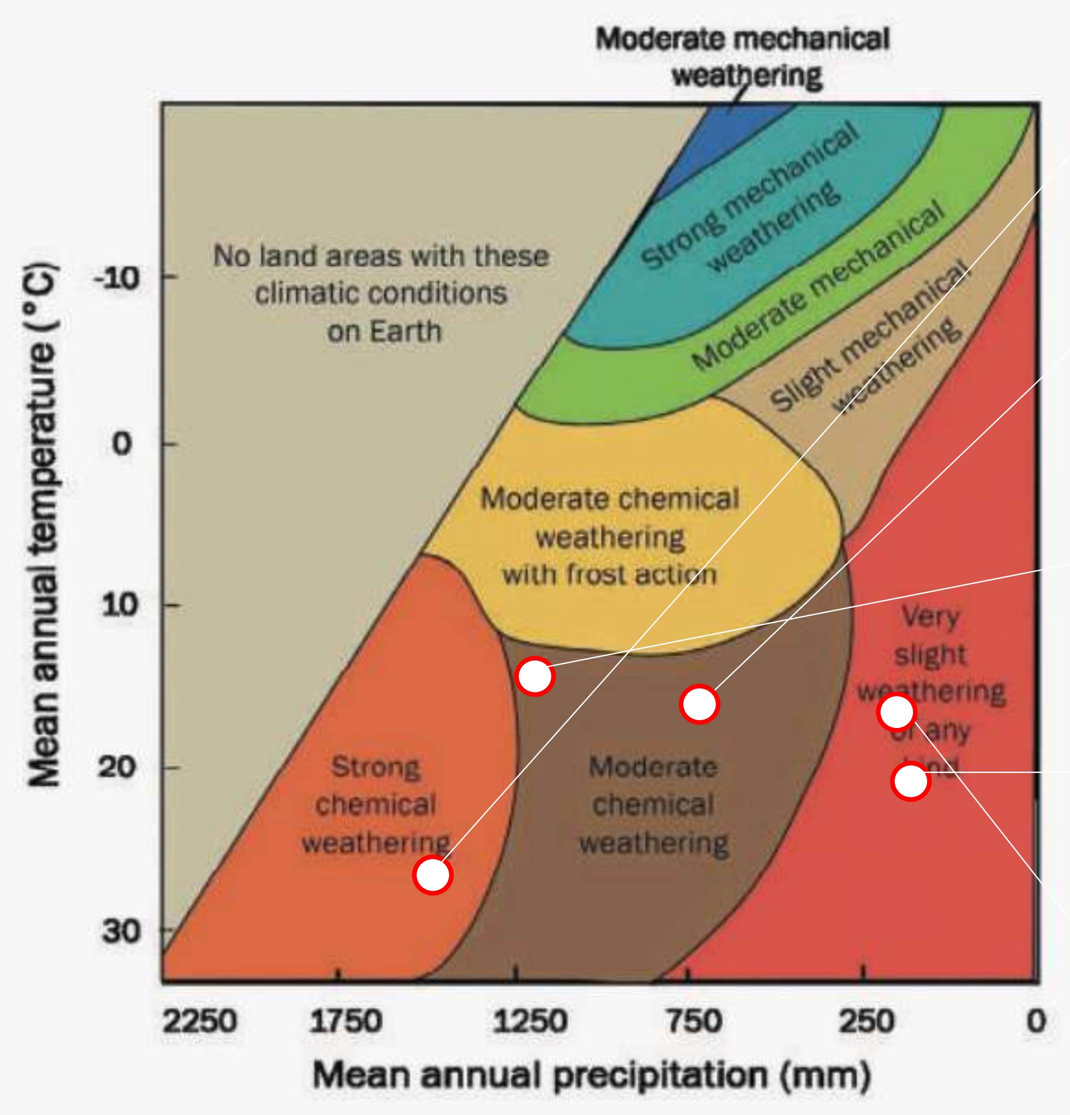
Scientific Interests: Mining geo-resources and mineralogical-petrographic applications for the environment and Cultural Heritage

fsitzia@uevora.pt

Researcher Geologist, Hercules Laboratory

https://www.cienciavitae.pt/portal/971E-D3D5-260F

https://www.linkedin.com/in/fabio-sitzia-77278a153/




Bangkok (Thailand) $T_{av}$ = 27.2°C, $r_{av}$ = 1557mm
(Equatorial climate Aw)

Lisbon (Portugal) $T_{av}$ = 17°C, $r_{av}$ = 725mm
(hot mediterranean Csa)

Porto (Portugal) $T_{av}$ = 14.4°C, $r_{av}$ = 1147mm
(warm mediterranean Csb)

Phoenix (Arizona, USA) $T_{av}$ = 21.5°C, $r_{av}$ = 204mm
(hot arid BWh)

Villasimius (Sardinia, Italy) $T_{av}$ = 17,9°C, $r_{av}$ = 238mm
(cold semi-arid BSk)

Peltier, L.C. (1950). The Geographic Cycle in Periglacial Regions as it is Related to Climatic Geomorphology. Annals of the Association of American Geographers, 40, 214-236.

# Natural sources of water

## Underground waters:

Circulating waters of deep or superficial aquifers. These are moderately saline waters often with TDS greater than 500mg/l. Their chemism reflects the lithology of the substrate and eventual ingressions of seawater. The pH is variable. Aquifer drinking water must have a 6.5<pH<9.5

## Seawater:

According to the basin, seawater has a variable TDS. In Mediterranean sea the total dissolved solids is 36<TDS<39g/l. The hydrogeochemical *facies* is Sodium Chloride. The pH is variable between 7.5 and 8.5 even if seawater is often basic

## Rainwater:

Precipitation water generally has a 2<TDS<20 mg/l with values up to 130mg/l. The chemism varies from sodium chloride to calcium sulphate and depends on the wind in charge or on the atmospheric particles. pH is variable, normally slight acid 5<pH<6.2. Alkaline rainwaters can have a 8<pH<11.

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# Interaction between water and stone

Within the stone, the water circulates essentially in three ways:

## 1) Porosity

Is the most complicated and common way for water circulation. It depends on open porosity, pore tortuosity, pores radius etc

## 2) Fracturing

The circulation of water by fracturing involved a lot of rocks typology, mainly siliceous. The amount of transported water and the circulation speed by fracturing modality are relatively high

## 3) Karst

The circulation of water by karst is typical of limestone rocks. The amount of transported water and the circulation speed by Karst modality are very high

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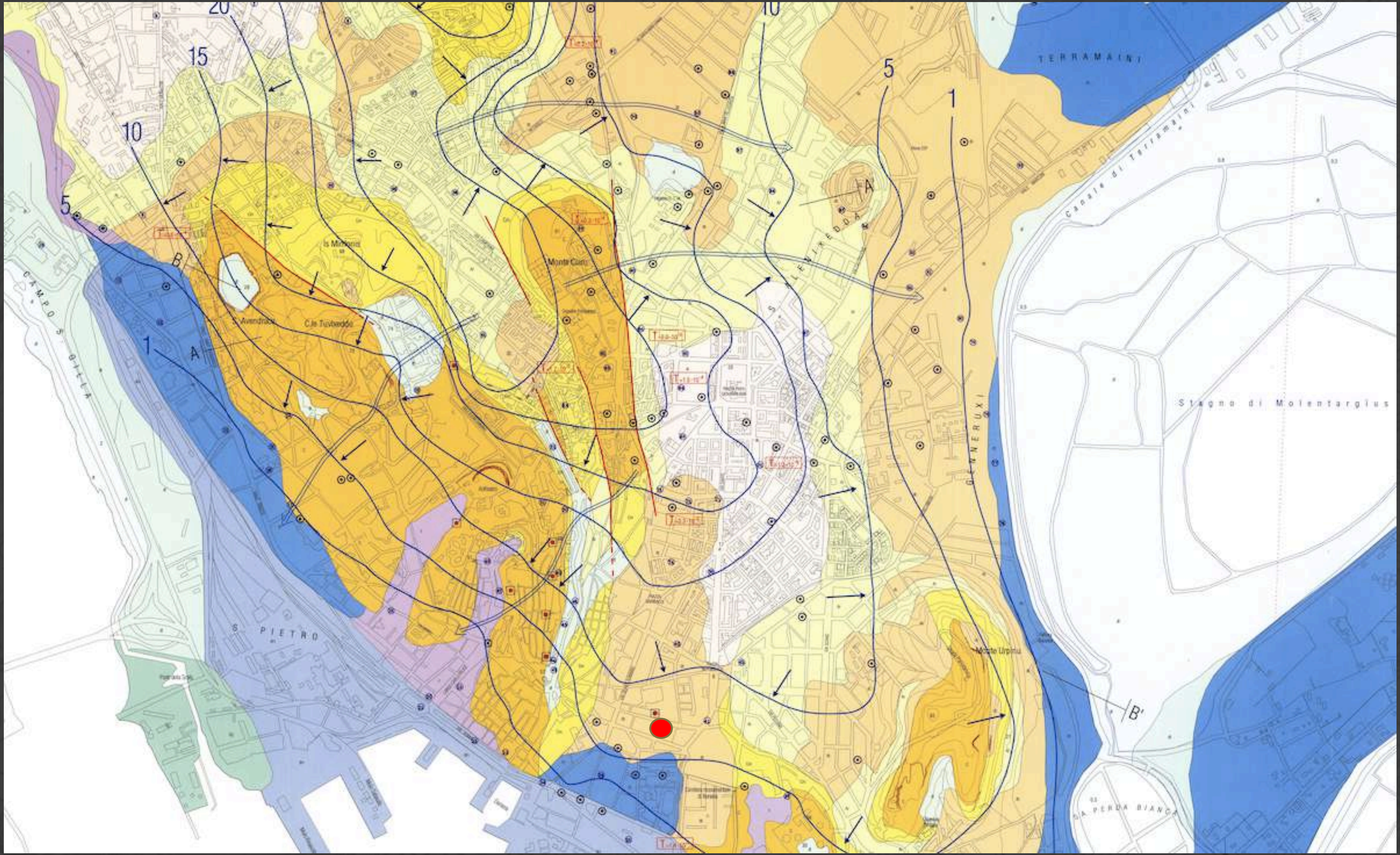
# Interaction between water and stone

Water-rock interaction does not occur only in large-scale natural environments. This process is also important in architecture where stone is utilised as building material

Water comes into contact with a building through the following ways:

1) Rainwater runoff
2) Capillary rising
3) Moisture and humidity
4) Residual from the moment of building construction
5) Extreme condition: flooding
6) Accidentals
7) Others



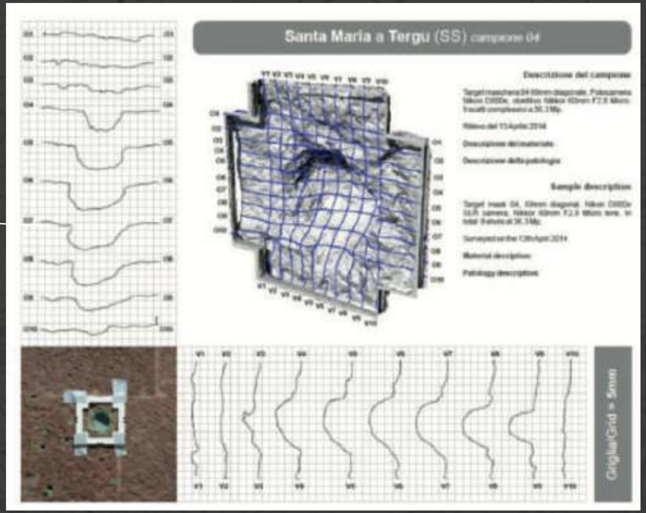

Carta idrogeologica di Cagliari, (Pala et. al 1997)

## Water Runoff

The runoff of water causes the proliferation of biological activities which act as a noble patina. The presence of higher plants, on the other hand, is harmful.

In correspondence with the water dumps, probably with an inadequate maintenance of the gutters, the wall has a surface runoff

This is causing a series of problems for the masonry which is starting to show erosion cavities. Monitoring on a photogrammetric basis takes place every 5 years to evaluate the erosion degree



# Rainwater and its corrosive effect

The rain water is naturally slightly acidic ($5.9 < pH < 6.3$) so it has remarkable dissolutive properties especially against limestones.

The dissolution effect is slow and difficult to observe macroscopically. However it can be identified when the surface of the stone has a polished finish

Corrosion of rainwater is essentially due to 2 main reasons:

1) High capacity of (TDS = 3mg/l) rainwater to dissolve atmospheric carbon dioxide forming carbonic acid. More TDS are present in the water, less is the capacity of $CO_2$ dissolution

2) Strong leaching capacity towards materials, not only natural stone but also plastic polymers, metals and alloys

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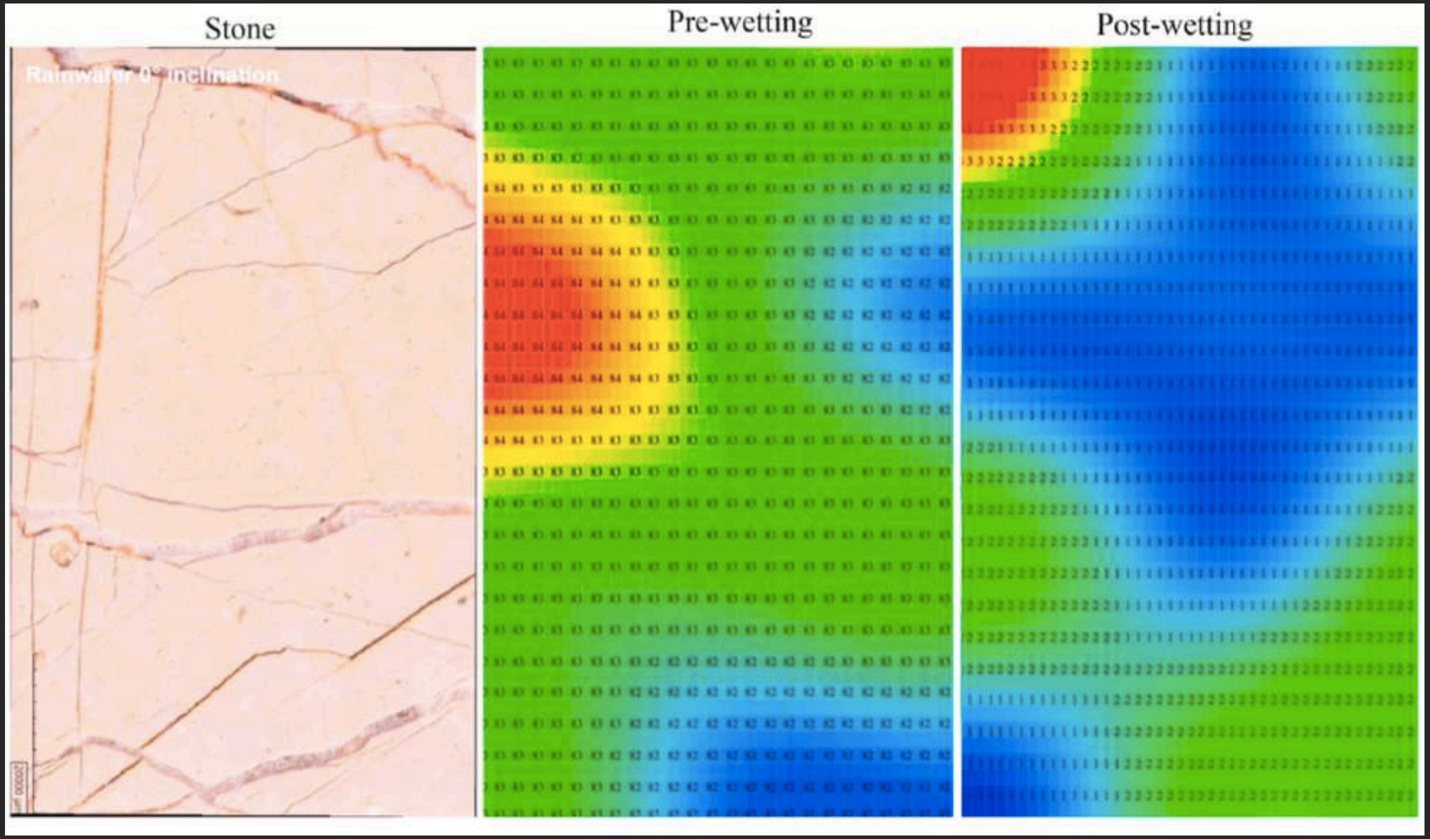
# Rainwater and its corrosive effect

The rainwater effect has been reproduced in laboratory (Hercules)
Polished stones were subjected to wetting by manual spraying




After 30 days of spraying the gloss of the stone changes from 82 to 1

More information at:


Contents lists available at ScienceDirect
Journal of Building Engineering
journal homepage: www.elsevier.com/locate/jobe
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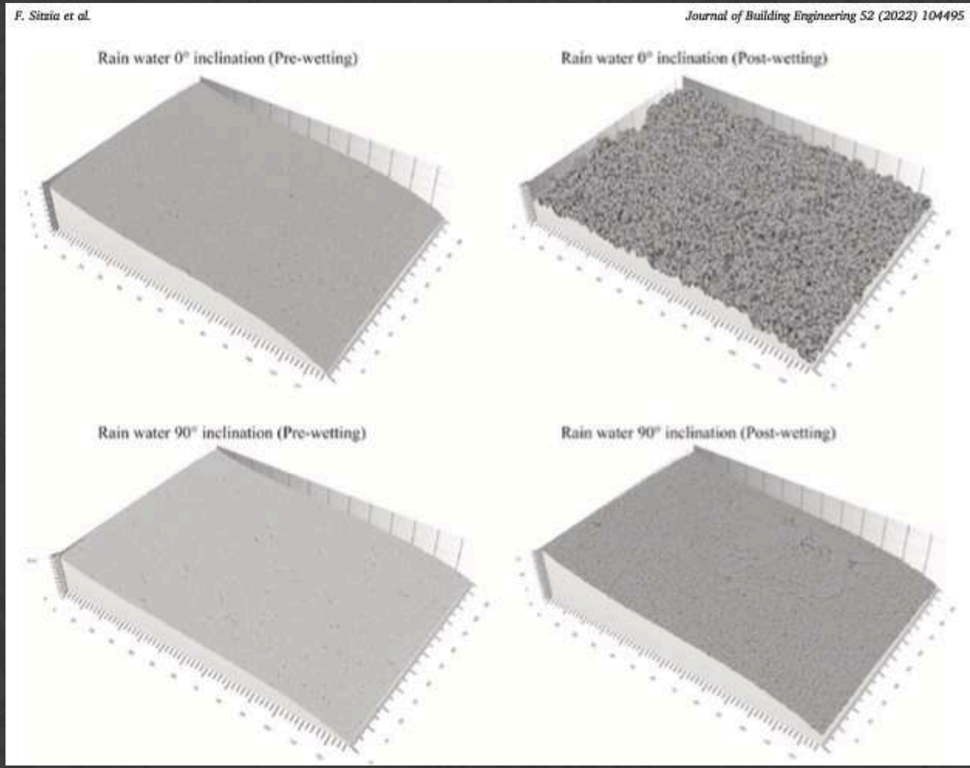
The interaction between rainwater and polished building stones for flooring and cladding - Implications in architecture


Fabio Sitzia [a,b,*], Carla Lisci [a,b], José Mirão [a,b]

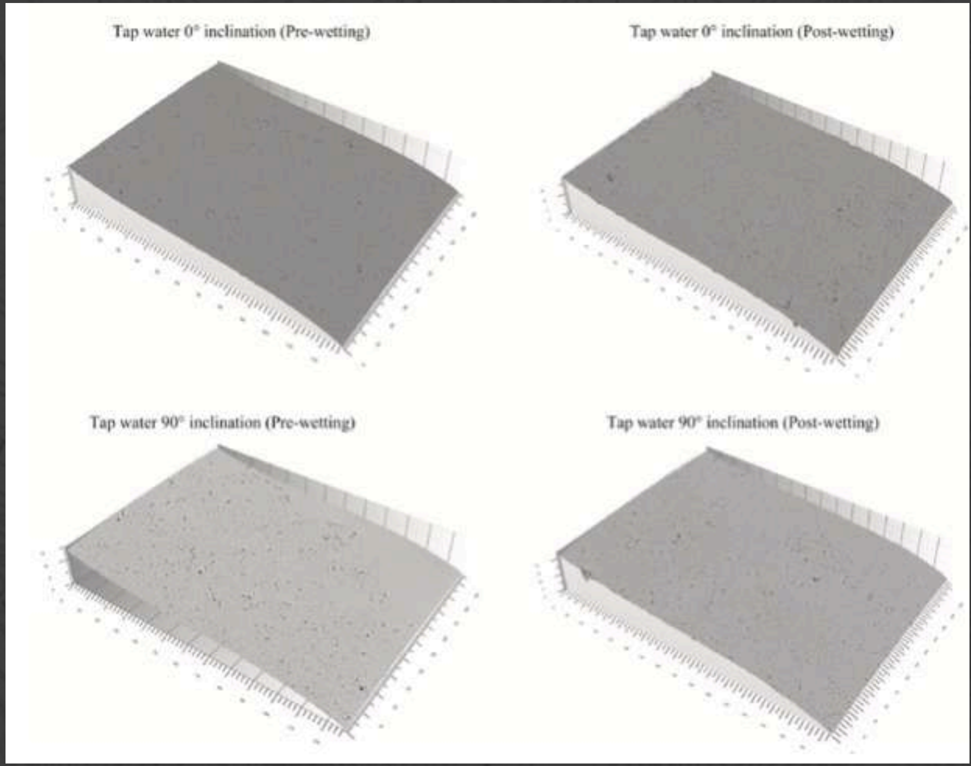
# Rainwater and its corrosive effect

Rainwater and tap water were used for the experiments
Experiment was carried out in a controlled environment at 15°C and 60% relative humidity

Rainwater TDS = 3mg/l



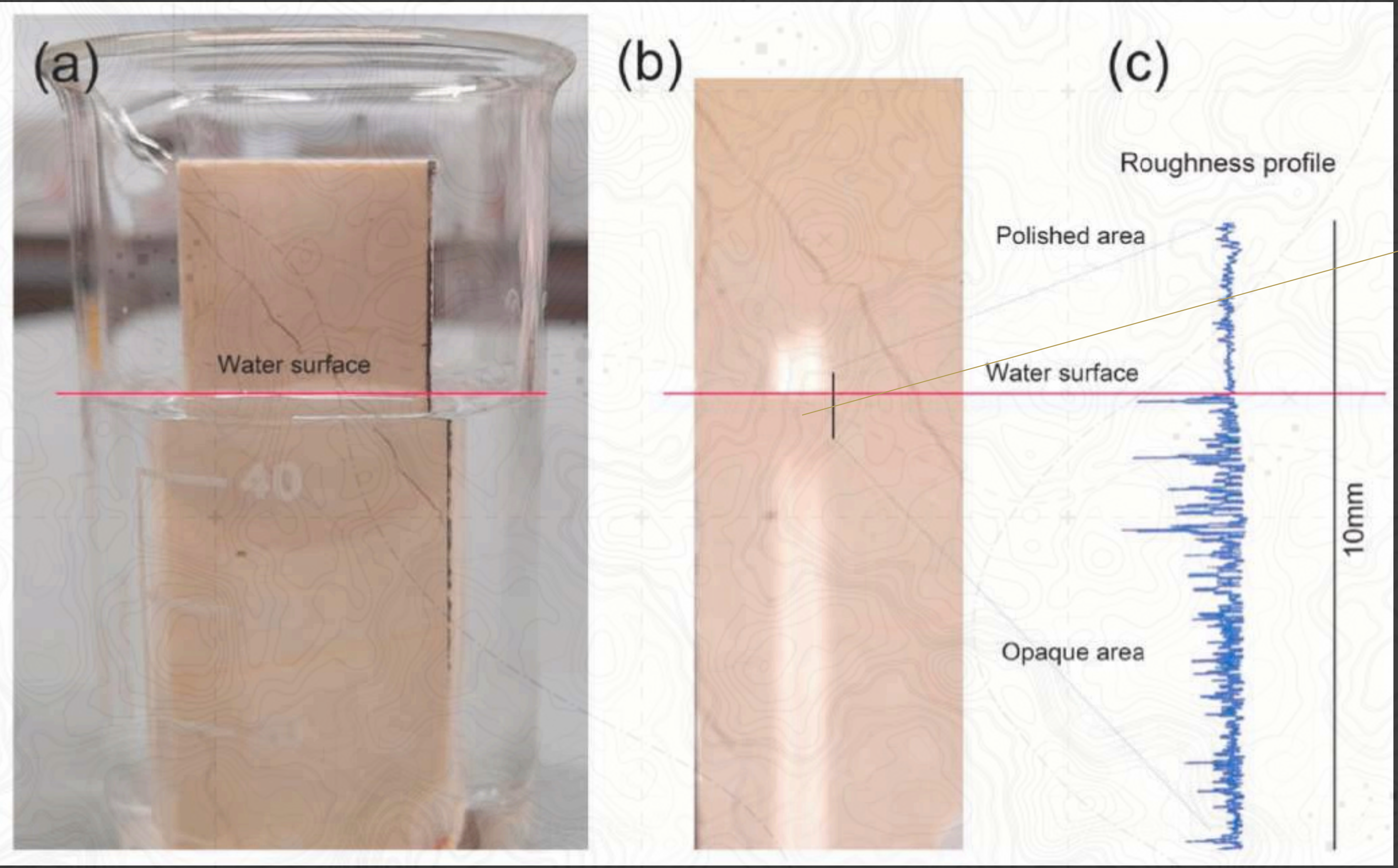

Tapwater TDS = 193mg/l




Micro-Photogrammetry by SEM microscope (Hercules Laboratory)

# Rainwater and its corrosive effect

Carla Lisci's rainwater experiment




Area of greatest production of carbonic acid $H_2CO_3$

# The effects of sunlight on stone materials

Sunlight in vacuum space is composed of about 50% infrared light, 40% visible light, and 10% ultraviolet light, for a total intensity of about 1400W/$m^2$

More than 95% of the total UV light is the longer wavelengths of UVA. UVB only represent 5% and almost no UVC reaches the Earth's surface. Ultraviolet rays can have interactions with the affected material depending on whether it is organic or inorganic in nature

Ultraviolet rays are considered the main cause of the color variation of materials

These color variations also occur on very resistant materials such as ornamental stone. In fact, different works correlate the amount of UV received over a period of time with the discoloration of the rock

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# The effects of sunlight light on stone materials

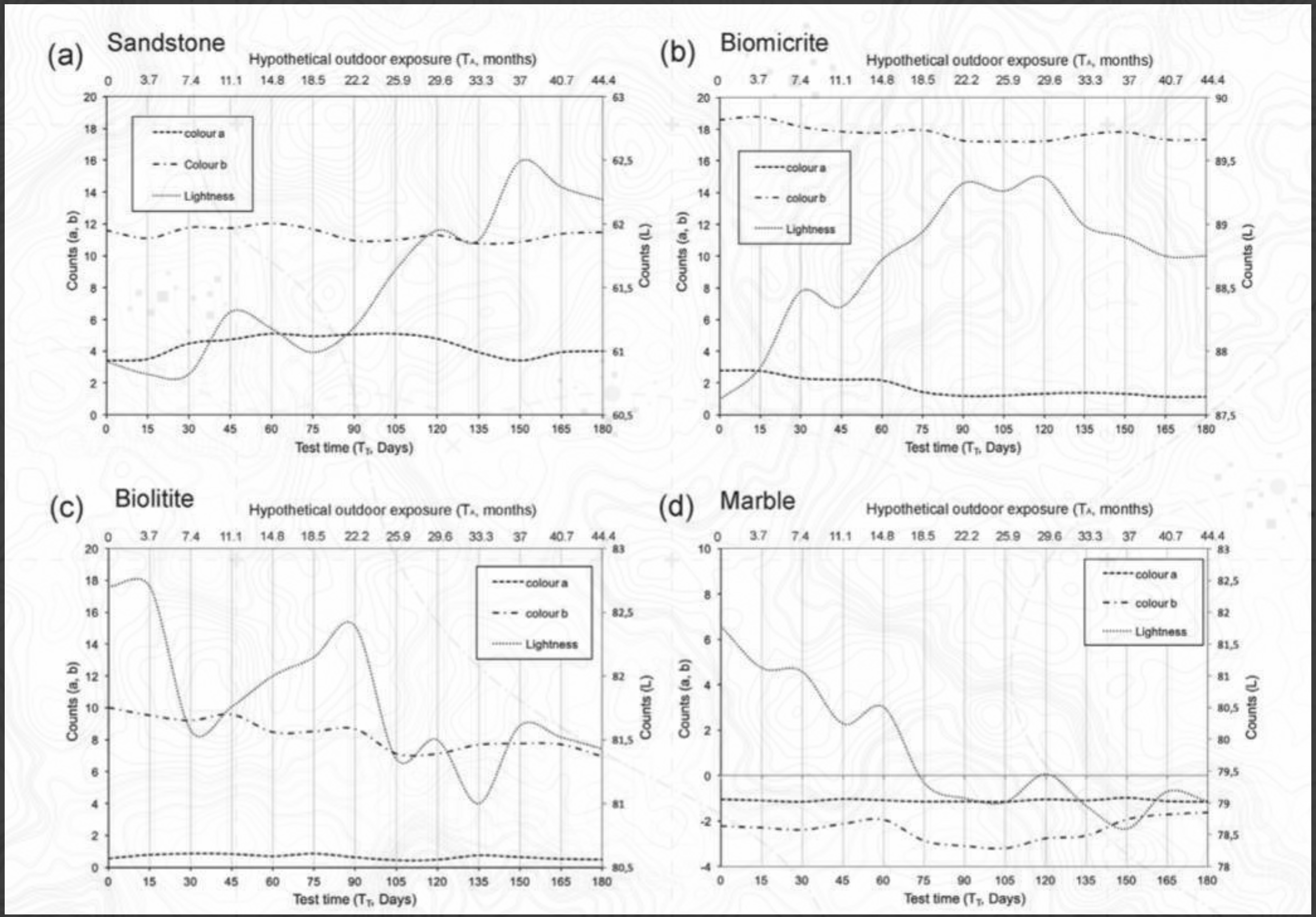
A test conducted for 6 months at the Hercules laboratory simulated exposure to sunlight in the 295-400nm wavelength (UVA + UVB) range on Limestones, Sandstones, Basalts, rhyolites, rhyodacites

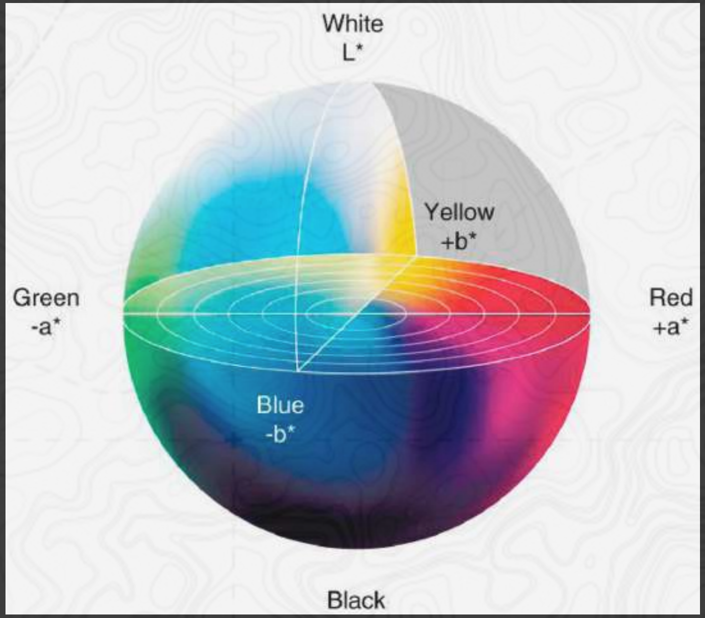
The experiment was conducted in a SOLARBOX solar chamber

According to the light intensity in SOLARBOX (700W/$m^2$) and the light intensity in the reference place (39 degrees North latitude), six months in climatic chamber corresponds to 44,4 months of outdoor exposure

The colours of the rocks have been monitored every 15 days according to CIE L*a*b* colour system classification

# The effects of sunlight light on stone materials



# The effects of sunlight light on stone materials

The process of color change on the rocks reflects the summation of the color changes of all the minerals present in it

Some colour changes may be reversible upon removal of the light source or through irradiation and usually do not alter the physical or chemical properties of the specimen as happens in some quartz ($SiO_2$) varieties.

As demonstrated by other authors some minerals like the Corderoite, ($Hg_3S_2CI_2$) from Miocenic Nevada sediments and the Hackmanite ($Na_8Al_6Si_6O_{24}(Cl_2,S)$) are considered photosensitive.

The first studies about photosensitive minerals have been carried out by Nassau. The author divides them into three groups

# The effects of sunlight light on stone materials

Light-induced colour changes without any other physical or chemical changes - may or may not be reversible (e.g., the faded colour of blue Celestite may return to its original colour if stored in the dark)

Light-induced decompositions producing significant bulk physical or chemical changes (LD) - irreversible effect (e.g., Cinnabar becomes darker with the conversion to black Metacinnnabarite, red Realgar transformation to yellow Pararealgar)

Light-accelerated surface reactions with air, moisture, and/or pollutants (LA) - irreversible effect (e.g., Vivianite darkens on exposure to light and with possible crystal decohesion.

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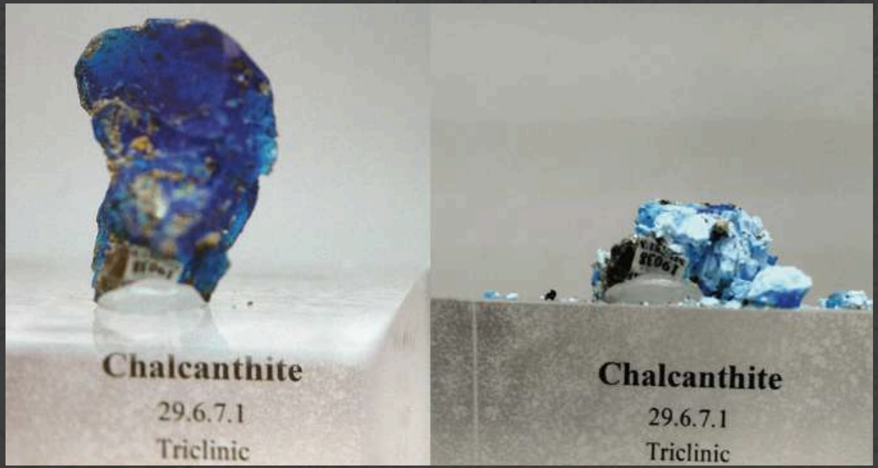
# The effects of sunlight light on stone materials




## Colour fading and changing in light-sensitive minerals exposed to UV rays

Fabio Sitzia*[a,b], Silvia Bottura Scardina[a], Patricia Moita[a,b], José Mirão[a,b]

[a] HERCULES Laboratory, Institute for Advanced Studies and Research, University of Évora, Largo Marquês de Marialva 8, 7000-809 Évora (Portugal)
[b] Geosciences Department, School of Sciences and Technology, University of Évora, Rua Romão Ramalho 59, 7000-671, Évora (Portugal)

Fabio Sitzia:
Água mole em pedra dura. A água e os materiais pétreos

That’s all folks!

Thanks