

KINETICS AND SURFACE ALTERATION OF LIMESTONE: IMPACT OF ACID SOLUTIONS ON THE SURFACE FINISHES OF MONUMENTAL STONES

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P a r i s

M. Fanfone^{(1)*}, F. Descamps⁽²⁾ and L. Debailleux⁽³⁾

(1) Architectural and Urban Engineering Unit, University of Mons, Faculty of Engineering (Belgium) (Morgane.FANFONE@umons.ac.be)

(2) Mining Engineering Unit, University of Mons, Faculty of Engineering (Belgium) (Fanny.DESCAMPS@umons.ac.be)

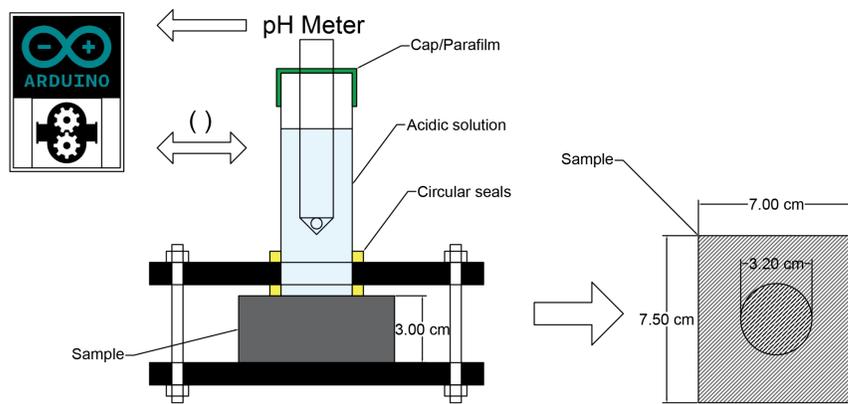
(3) Architectural and Urban Engineering Unit, University of Mons, Faculty of Engineering (Belgium) (Laurent.DEBAILLEUX@umons.ac.be)

“One stone - different faces: From finish to fading: how stone-cuttings influence decay and authenticity under acidic attack”

1 Context

In Architecture Heritage, craftsmanship marks and cuttings on limestone surface tend to degrade facing to acid-induced weathering. We study the **surface evolution** to understand **material loss**, the influence of initial **roughness** on degradation, the impact of **nature and particularities** of the stone, **stone cutting** and on **heritage value**. (1,2)

Experiment configuration

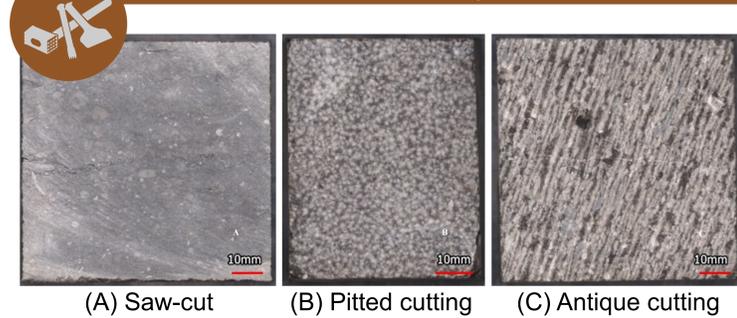


2 Material & Methods

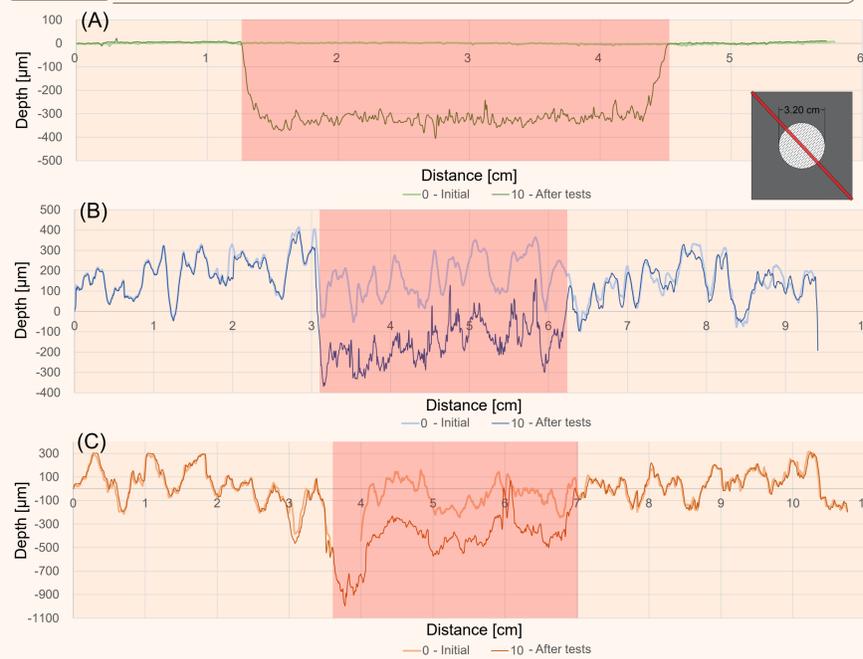
Belgian Blue Stone (BBS)

Density	2689 kg/m ³	Porosity	Less than 1%
Composition	96-99% Ca, fossils, quartz, dolomite, pyrite,...	Type	Carboniferous grey-bluish crinoidal limestone
Test	Partial Immersion of a finished surface (3,4)	Solution	Acidic solution (7%, CH ₃ COOH, pH 2.44)

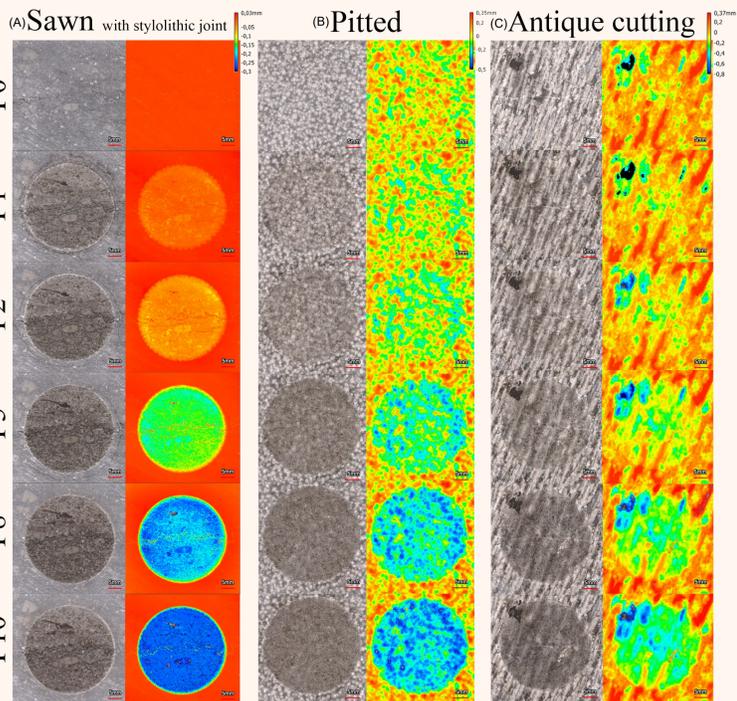
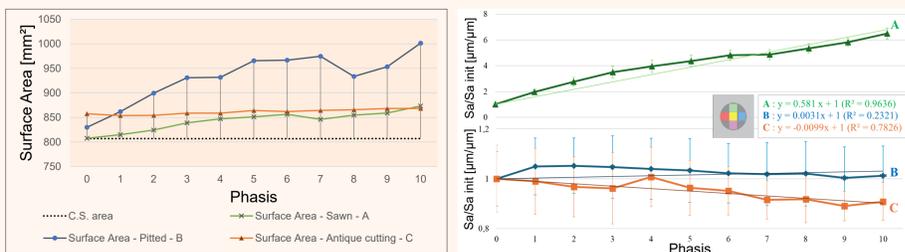
Stone-Cuttings



3 Results



All stone-cutting profiles show a loss between phase 0 and phase 10. (A) and (B) exhibit an increase in surface area, whereas surface area (C) remains nearly constant, through altered.



Height range and optical image of each type of finished surfaces obtained with 3D optical profilometer Keyence, from the initial phase to phase 10.

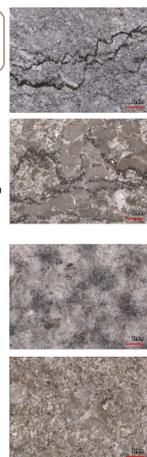
$$S_a = \frac{1}{A} \iint_A |Z(x,y)| dx dy \quad S_z = S_{peak} + S_{valley}$$

S_a (Arithmetic Mean Surface Roughness) S_z (Maximum Surface Roughness Height)

	Sa_mean_P0 (st.dev.) [µm]	Sz_mean_P0 (st.dev.) [µm]	Sa_mean_P10 (st.dev.) [µm]	Sz_mean_P10 (st.dev.) [µm]
(A)	3,85 (0,92)	58,25 (15,66)	24,97 (1,66)	463,35 (13,89)
(B)	67,52 (7,44)	503,54 (33,16)	68,35 (8,01)	675,74 (66,91)
(C)	91,51 (12,33)	664,71 (122,73)	83,08 (6,99)	792,79 (40,35)

4 Conclusions

- Surface finishing techniques significantly influence the degradation of stone under acidic conditions. (A) seems more sensible with a more rapid dissolution.
- Material loss remains limited (~0.3 mm after 10 cycles), but enough to alters tool marks, reducing the legibility of original finishes.
- The anisotropy and heterogeneity of the rock, as well as the exposed texture, modify the alteration dynamics (exposed fossils, stylolithic joint...).
- Authenticity and heritage value of the stone are compromised by the evolution of the alteration.
- Prospects:
 - Test other acid solutions (HNO₃, H₂SO₄) to simulate varied acid rain.
 - Assess manually trimmed or historic surfaces to estimate their long-term resistance.



5 References

- (1) Doperé, F., 2018, Dater les édifices du Moyen Âge par la pierre taillée.
- (2) Molina, E., et al, 2020, Influence of Surface Finishes and a Calcium Phosphate-Based Consolidant on the Decay of Sedimentary Building Stones Due to Acid Attack.
- (3) Gibeaux, S., et al., 2018, Simulation of acid weathering on natural and artificial building stones according to the current atmospheric SO₂/NO_x rate.
- (4) Vázquez, P., et al., 2016, Influence of surface finish and composition on the deterioration of building stones exposed to acid atmospheres.



Morgane Fanfone



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