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Assessing thermal interactions during laser cleaning by means of infrared thermal imaging

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Laser ablation is not only a well established technique for cleaning inorganic black crusts on historic building limestone but also a potentially effective method to remove lichens and other organic encrustations from building materials, although this application has not been deeply assessed up to now. In both cases, effective cleaning is ultimately dependent on thermal processes generated by laser pulses. Infrared thermography allows the acquisition of the thermal response of the cleaned area during the laser irradiation process and therefore it is a useful tool to assess the relations between thermal interactions and effective cleaning. This communication presents some preliminary results on thermal imaging analyses of laser cleaned encrusted carbonatic rocks. Samples of limestone and dolostone with either a several millimetre gypsum black crust or a thin biological crust (crustose lichens, such as Verrucaria nigrescens and different lithobionthic microorganisms) were cleaned with infrared nanosecond laser pulses using the fundamental (1064 nm) output of a Q-switched Nd:YAG laser system (pulse duration 5 ns, repetition rate 1-10 Hz). Two types of microbolometer-based cameras, working within the 7.5 to 13 μm spectral range, were used to acquire IR images at several frequencies to observe the temperature evolution during laser cleaning of both black and biogenic crusts, and compare it with calculated temperature distributions. Different image resolutions and frequencies were used to explore the limitations of this technique both in temporal and spatial scales. Images were analysed with different methods: absolute values of thermal increment were mapped and phase and amplitude maps were extracted. Results allow characterizing the different heat transfer patterns through both crusts and substrate and the rock heating gradients (and therefore possible thermal shock effects) as well as monitoring relevant temperature thresholds, such as the temperature of thermal oxidation of iron (ca. 300 ºC) that leads to rock discolouration and denaturing temperature for lichenic proteins (ca. 40 ºC).

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