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Wind driven saltation: a hitherto overlooked challenge for life on Mars

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The Martian surface is a hostile environment characterized by low water availability, low atmospheric pressure and high UV and ionizing radiation. Furthermore, wind-driven saltation leads to abrasion of silicates with a production of reactive surface sites and, through triboelectric charging, a release of electrical discharges with a concomitant production of reactive oxygen species. While the effects of low water availability, low pressure and radiation have been extensively studied in relation to the habitability of the Martian surface and the preservation of organic biosignatures, the effects of wind-driven saltation have hitherto been ignored. In this study, we have investigated the effect of exposing bacteria to wind-abraded silicates and directly to wind-driven saltation on Mars in controlled laboratory simulation experiments. Wind-driven saltation was simulated by tumbling mineral samples in a Mars-like atmosphere in sealed quartz ampoules. The effects on bacterial survival and structure were evaluated by colony forming unit counts in combination with scanning electron microscopy, quantitative polymerase chain reaction and life/dead-staining with flow cytometry. The viability of vegetative cells of P. putida, B. subtilis and D. radiodurans in aqueous suspensions was reduced by more than 99% by exposure to abraded basalt, while the viability of B. subtilis endospores was unaffected. B. subtilis mutants lacking different spore components were likewise highly resistant to the exposure to abraded basalt, which indicates that the resistance of spores is not associated with any specific spore component. We found a significant but reduced effect of abraded quartz and we suggest that the stress effect of abraded silicates is induced by a production of reactive oxygen species and hydroxyl radicals produced by Fenton-like reactions in the presence of transition metals. Direct exposure to simulated saltation had a dramatic effect on both D. radiodurans cells and B. subtilis spore with a more than 99.9% decrease in survival after 17 days. The high susceptibility of the usually multi-resistant D. radiodurans cells and B. sublitis spores to the effects of wind-driven saltation indicates that wind abraded silicates as well as direct exposure to saltation represent a considerable stress for microorganisms at the Martian surface, which may have limited the chance of indigenous life, could limit the risk of forward contamination and may have degraded potential organic biosignatures.