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Extreme limestone weathering rates due to micron-scale grain detachment

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Chemical dissolution is often assumed to control the weathering rates of carbonate rocks, although some studies have indicated that mechanical erosion could also play a significant role. Quantifying the rates of the different processes is challenging due to the high degree of variability encountered in both field and lab settings. To measure the rates and mechanisms controlling long-term limestone weathering, we analyse a lidar scan of the Western Wall, a Roman period edifice located in Jerusalem. Surface retreat rates in fine-grained micritic limestone blocks are found to be as much as 2 orders of magnitude higher than the average rates estimated for coarse-grained limestone blocks at the same site. In addition, in experiments that use atomic force microscopy to image dissolving micritic limestone, we show that these elevated reaction rates could be due to rapid dissolution along micron-scale grain boundaries, followed by mechanical detachment of tiny particles from the surface. Our analysis indicates that micron-scale grain detachment, rather than pure chemical dissolution, could be the dominant erosional mode for fine-grained carbonate rocks.