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Negative feedback between stress and erosion: origin of sandstone landforms

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Weathering and erosion of sandstone produces spectacular landforms such as arches, alcoves, pedestal rocks and pillars. The effect of gravity loading stress has been overlooked or assumed to increase the landform's weathering rate. Here we show by physical and numerical modeling, and field observations of locked sands and sandstones that an increase in stress within the landform reduces weathering and erosion. Material with insufficient loading is rapidly removed by weathering process and the remaining load bearing landform structure is protected by the fabric interlocking mechanism. As the landform evolves the increased stress inhibits erosion from raindrop impact, flowing water and slaking, and retards surface retreat caused by salt and frost weathering. Planar discontinuities in sandstone and negative feedback between stress and weathering/erosion processes are sufficient conditions to create above-mentioned landforms. Our experiments are able to reproduce natural shapes including arches, alcoves, pedestal rocks and pillars using landform material and mimicking natural processes. The proposed negative feedback mechanism is supported by a numerical model of stress pattern in landforms. We conclude that stress field is the primary control of the shape evolution of sandstone landforms.