The role of rock fracture in Martian landscape evolution

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The 27 km journey across the floor of Gale Crater and up the footslopes of the 5 km high Mt. Sharp that occupies the center of the crater has revealed a rich stratigraphic history of fluvial, lacustrine, and aeolian sediments. These deposits were buried, lithified, altered by diagenesis, and subject to billions of years of wind driven erosion which etched out the strength variability of the bedrock, leading, in particular, to resistant sandstone caps on underlying mudstones forming isolated buttes and steep retreating bluffs. Wind has also shaped less strongly lithified bedrock into oriented rounded hilltops. All of the bedrock is broken. Many processes are likely at work to break the rocks including impacts, differential heating, periglacial processes, wetting and drying, and, perhaps topographic-induced stresses. Breaking the rocks enables cliff retreat and shedding of blocks on rounded hillslopes. This breaking, however, also becomes an erosional rate limiting step on retreating bluffs and scarps because the loosen blocks form a slope mantle reducing wind erosion. The intention of this talk is to invite a mechanistic analysis of the relative roles various rock break processes may play and to ask what measurements "in the field" with the Curiosity rover could be done to test proposed mechanisms.

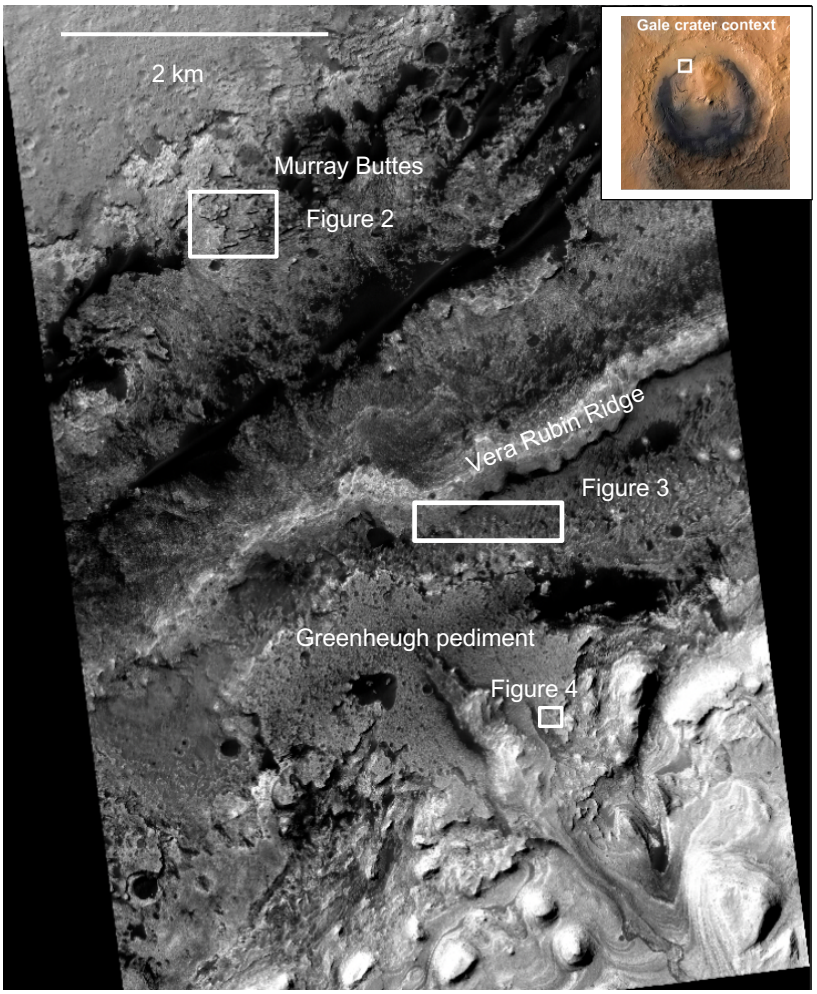

Figure 1. HiRISE image of the footslope of Mt. Sharp. Lithologic variations that influence the hardness and size of bedrock fracture blocks have controlled the pattern of wind eroded topography over 3 billion years.

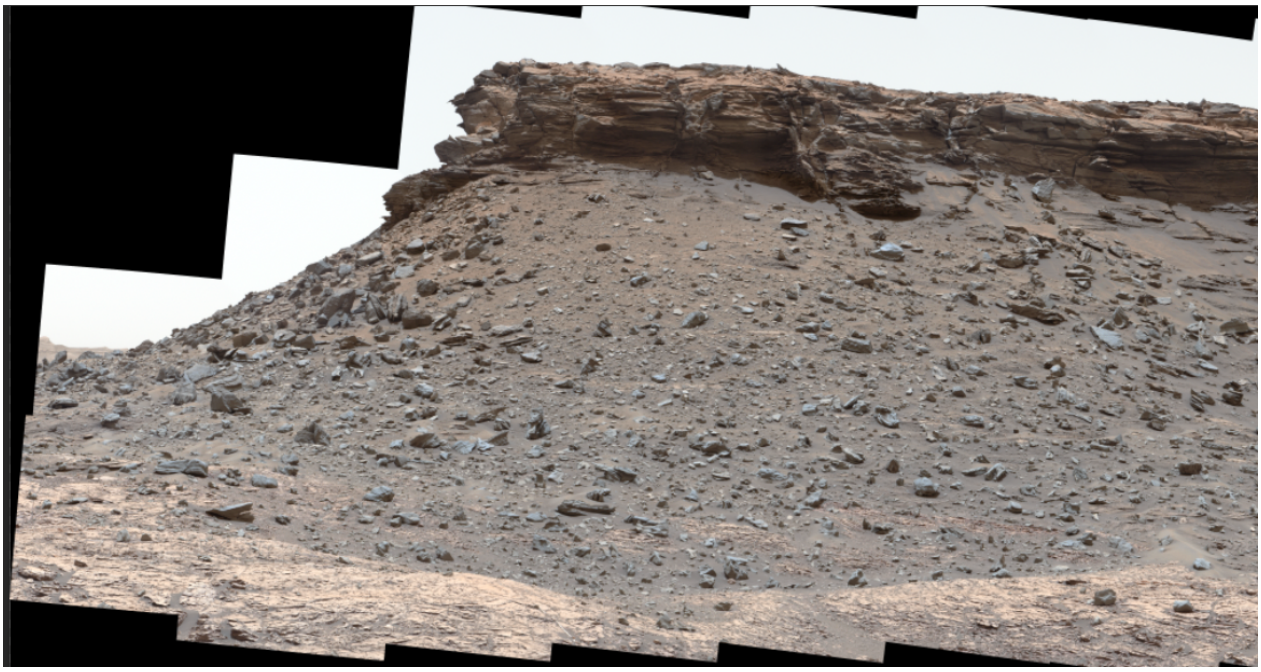

Figure 2. Blocks shed from the capping sandstone unit (Stimson Formation) mantle the slope and protect it from wind erosion (through both physical resistance to wind erosion and through roughening the surface and thus reducing wind entrainment stress). Exposure age dating on the light toned underlying unit (lacustrine Murray Formation) at the base is 1.46 billion years (Martin et al., 2021). Note the lack of blocks beyond the break in slope at the base. Butte height is ~ 8 m.

Figure 3. To the south of Vera Rubin Ridge, fluvial and lake deposits break into small gravel sizes. Wind erosion has consequently created a field of periodic bedrock ridges spaced at about 30 m apart and commonly less than 1 m high (Stack, in press).

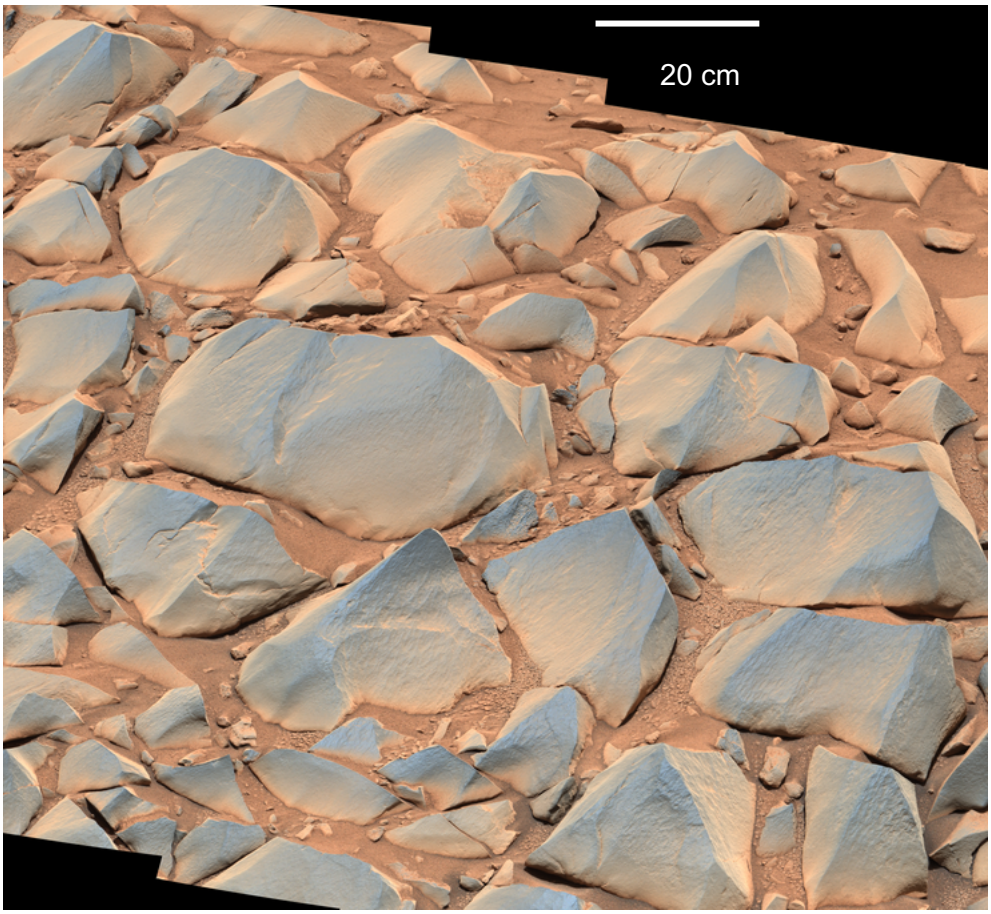

Figure 4. On parts of the Greenheugh pediment surface the sandstone has broken into blocks which have then been shaped and sharpened by wind erosion. This surface may have been exposed for ~3 billion years (Palucis, et al., 2021; Palucis, et al., 2016)

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