

**WIND AND THE ORIGIN OF MARTIAN GULLIES: A LOCAL AND REGIONAL TEST IN CIMMERIA.**

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Martian gullies are composite landforms, representing massive transport of debris down a slope [1]. Most explanations of gullies involve liquid water (groundwater, ground ice, snowmelt), and two have invoked wind and eolian deposition. Gullies might form by solar melting of dust-ice mantles, which were wind-deposited onto wind-facing slopes [2]. Or gullies might form as dry flows of sand and dust, wind-deposited in the lee of obstacles like crater wall [3]. I test these hypotheses using a crater and surroundings in Cimmeria, where wind direction has been relatively constant (to SE). In this area, most gullies face S and SE, to the lee of the prevailing winds, as predicted in [3].

**Methods:** Inspired by the impact crater and its gullies in MOC press release MOC2-1302 (Fig. 1), I examined MOC and Themis [4] images of the area surrounding it in Cimmeria (MC-29). I noted the locations and facing directions of gullies, and of wind direction indicators (especially wind streaks).

**Crater 1302:** The inspiration for this work, called impact crater 1302 (Fig. 1), is a relatively fresh simple bowl, ~4 km diam., in Cimmeria (35.4°S 152.5°E). Crater 1302 is excavated in rolling Noachian plains material [5], and sits on a broad low rise with indistinct fluvial (?) channels to the south. Much of the crater's geology reflects deposition and erosion from winds blowing NNE to SSW. {1} The crater floor is marked by elongated hills (yardangs) aligned NNE-SSW along broad streaks of lighter and darker tone materials. {2} Dune forms decorate the boundary between 1302's floor and walls. At the north edge of the floor are long linear dunes oriented E-W (~parallel to the nearby crater rim); at the south edge of the floor are many short linear dunes oriented N-S (perpendicular to the nearby crater edge). {3} Linear dunes on the plains surrounding 1302 appear asymmetrical, with steeper (slip) faces to the SSE. Linear dunes near 1302 have more divergent orientations, with slip faces to the S and E.

Crater 1302 has gullies on its S- and W-facing interior walls (Fig. 1, MOC E0101585). On the former wall, overlapping debris deposits imply at least three episodes of gully formation from the same alcoves. The deposits are cut by minor circumferential faults, and pitted as by wind etching. Walls between alcoves show at least one episode of sediment deposition followed by etching.

Thus, recent geological processes at crater 1302 are dominated by eolian effects ascribable to winds blowing towards the S and SE. Gullies on the interior walls



Figure 1. Crater 1302 (MOC S1000476). Above: abundant gullies on S-facing interior wall. Transverse dunes below gullies on floor; central floor with N-S wind streaks and yardangs, and longitudinal dunes at S edge of floor. Below: detail of gullied wall.

of crater 1302 also face to the S and E, which is as predicted if they form from sediment deposited (behind obstacles) from winds blowing to the S and E [3].

**Regional Setting:** Crater 1302 might be atypical, so I investigated wind direction markers and gully orientations in Cimmeria surrounding 1302. Wind orientations from wind streaks are shown in Figure 2a; the area of crater 1302 is in a broad area of consistent southeasterly winds [6], with a few windstreaks indicating other directions. GCM results for this area are consistent with the streaks, and imply that wind directions vary little with season or storm condition [7].

Most gullies in this part of Cimmeria face to the south or southeast ([8], Fig. 2b). Despite this variability in gully facings, it is clear that the majority of gullies face in the same direction as the present-day winds blow (Fig. 2a).

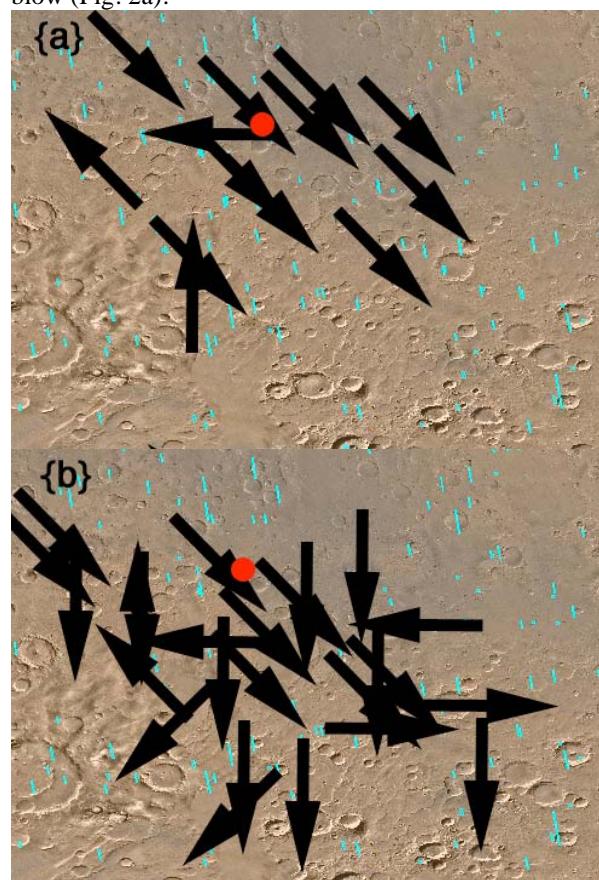


Figure 2. Orientations of selected features in part of Cimmeria (MC-29), 140-170°E, 30-52°S, north to top. Base is MOC mosaic. Red dot is crater 1302 (Fig. 1). Blue bars are MOC image locations (R10-R15). {a}. Windstreaks, arrowhead to inferred wind direction. {b}. Gullies, arrowhead in facing direction (i.e., downhill).

**Interpretations:** Evidence uncovered here is most consistent with gullies in this part of Cimmeria forming from wind-deposited dust and sand.

The gullies in crater 1302 and environs are not easily explained in the model of [2], which starts with dust-ice mixes plastered onto wind-facing slopes. Were that so, prevailing winds from the NW would place the

dust-ice mixtures onto the NW-facing walls of craters, where very few gullies are observed (Fig. 2b). Nor is dust-ice deposition onto lee slopes (facing S & SE) likely, because the ice would have to travel from the northern hemisphere, across the equator.

Hypotheses of gully formation invoking groundwater [9] remain problematic [10]. Rock in the walls of impact craters (Fig. 1) is too broken to support aquifers and aquitards, so groundwater cannot easily be present near alcove sites to initiate gullies. Hypotheses relying on ground ice seem unlikely here because, in the vicinity of crater 1302, little near-surface H is detected [11], and ground ice is calculated to be unstable [12].

Finally, evidence developed here is consistent with the model of [3], in which gullies develop from wind-deposited dust and sand. Wind directions in crater 1302 and surrounding Cimmeria are dominantly to the S and SE, as shown by several types of markers and by GCM simulations. The recent geology of crater 1302 is dominated by eolian effects, indicating that wind is an active geologic agent. Most gullies in crater 1302 and its surroundings are on S- to SE-facing walls, which would be in the lee of the prevailing winds, as predicted by [3].

**Extensions:** Several other ideas on the eolian origin of gullies have come from this study. {1} Gullies need not originate at their alcoves, but can enlarge uphill to form alcoves [13]. {2} Gullies can only form in areas of alternating deposition and erosion of dust/sand. {3} Gully formation is episodic; no large gullies have formed in the years of high-resolution Mars observations [14], so may require wind events more severe than witnessed so far. These ideas can be discussed as time permits.

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