SAND, WIND, AND ICES ON MARS: HOW SANDY ENVIRONMENTS FACILITATE EROSION BY CO_2 JETS.
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Dunes in the martian polar areas are among the most active environments on the planet. Interaction between wind, sand, CO_2 and H_2O ices creates the most enigmatic processes and phenomena that have no terrestrial analogs. Dark and bright fan deposits, dark downslope streaks, seasonal polygonal cracks, dark and bright banding (or "fried eggs"), are among those observed by HiRISE and CaSSIS cameras through the last 7 martian years. [1, 2, 3].

Seasonal processes that involve CO_2 and H_2O condensation and sublimation consistently repeat every year with some differences between the years [4]. Alongside seasonal features that disappear when seasons change, there are those that stay on dunes and on the underlying substrate for longer periods of time: creation of new alcoves and gullies, formation of furrows, and creation of dendritic troughs near dunes in the southern hemisphere are among the processes that actively modify surfaces [5, 6, 7]. CO_2 condensation and sublimation plays a role in all of these. The exact mechanism behind alcove and gully creation is debated. However, creation of the dendritic troughs is believed to be by the cold CO_2 jet eruptions and subsequent erosion of the substrate according to the Kieffer's model [5, 8, 9].

Kieffer's model builds on the specific optical properties of the seasonal CO_2 ice layer. The sunlight that is able to penetrate through the layer of translucent ice in the beginning of spring, deposits solar energy on layers' lower boundary, i.e. where the ice meets top of the regolith. The solar energy is transferred into sublimation of the ice at this boundary. It builds up the pressure in the cavity below the ice layer and at some point the pressurized gas is able to break through the ice, creating a CO_2 jet. At the moment of eruption, pressurized gas inside the cavity moves toward the opening in the ice with high velocity. On its way, it picks up some unconsolidated dust and regolith, disturbs and destabilizes the substrate, and thus creates the sub-ice troughs. This is how araneiforms (or spiders) are believed to be

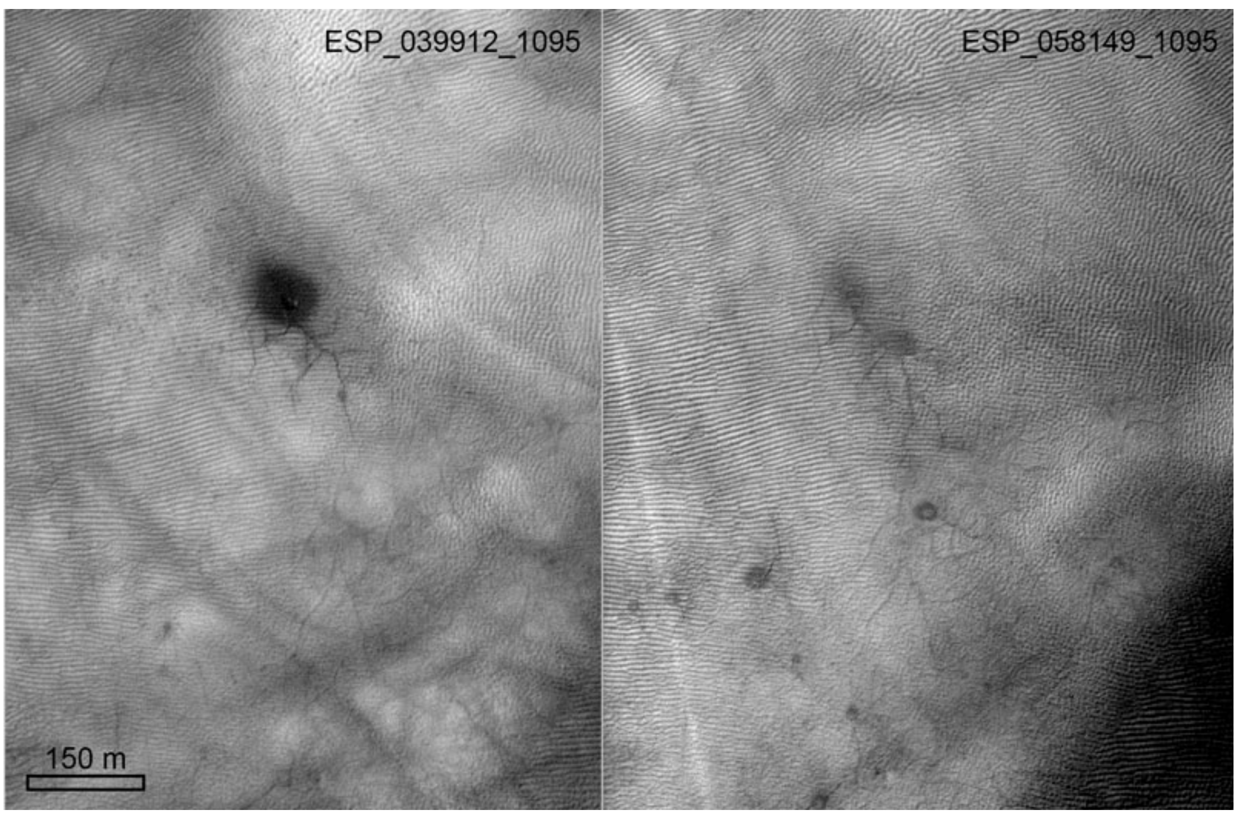

Figure 1 Development of new troughs in the vicinity of dunes: HiRISE images ESP_039912_1095 and ESP_058149_1095 are from southern summer of MY32 and MY33 respectively. This location is nearby a dune field. We hypothesize that troughs are created faster in this area relative to other locations monitored by HiRISE because loose sand is present on the surface and acts as abrasive during CO_2 jet eruptions.

created.

Somewhat surprisingly, after 7 martian years of monitoring multiple locations with active araneiforms, HiRISE is yet to see changes in them or the surrounding substrate that can be linked to this process. HiRISE observes seasonal changes, i.e. albedo variations in locations where CO_2 jets erupt and create fan- and blotch- shaped deposits on top of the seasonal layer. HiRISE observes them being created and later fading when seasonal ice sublimes away. But it has not yet detected topography changes in any pre-existing araneiform shapes. However, HiRISE has detected new dendritic troughs in several locations, all of them near dunes.

In the case when the seasonal CO_2 layer covers dunes, the whole process gets intensified in two ways: first, the albedo of martian sandy dunes is usually low and thus the whole process is more energetic because dark sand absorbs more sunlight that intensifies the sublimation of CO_2, which turns on jet eruptions. Second, dunes always have a layer of unconsolidated sand. It can be easily picked up by the gas moving towards the opening in the ice. Presence of suspended sand in the pressurized and fast moving gas increases the abrasive effect of such a flow. We hypothesize that troughs are created faster in the areas where loose sand is present on the surface compared to other locations monitored by HiRISE. This might explain the apparent lack of erosion in the areas of large araneiforms while new dendritic troughs appear in the other places.

The idea of sand being an essential component of Kieffer's model challenges several ideas about araneiforms. First, if sand is required to erode polar surface into araneiforms, does erosion stop entirely if the sand is removed? If removal of sand from an area can stagnate the araneiform development in this area, is the opposite true as well? Can a new source of sandy material facilitate or accelerate araneiform growth? Following along this line of argument, we must embrace an even larger degree of stochasticity in the evolution of araneiforms. Estimation of araneiform ages may need to include discussion of availability of sandy material in the polar areas over geologic periods and how those periods interlace with presence of CO_2 ice on the surface.

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