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Water-related formational process of gullies on sand dunes in Russell >> crater

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Various kind of water-related features have been observed on the surface of Mars. Among them, one of the most actively-debated is gullies because some of them are found to be active even now. Although their formational processes are still not clearly understood, they should hold important keys to understand the present-day water activity on the surface of Mars.
A gully is a general term applied to a small, linear, seemingly young erosional feature incised into a steep slope, such as a crater wall, a crater central peak, a wall of a valley, and a pit. Gullies are typically ~10m in width and hundreds of meters in length, which contrasts to much larger scale features such as outflow channels and valley networks. Most gullies are observed in the southern hemisphere at latitude higher than 30 deg. They typically consist of an upper, theater-shaped alcove that tapers downward to converge into one to several channels, which extend further downslope. Commonly they terminate in triangular debris aprons, which are often called fans. These characteristics are most commonly explained in association with liquid water. However, the source of water is controversial. Several sources of water are suggested, such as groundwater seepage based on the fact that arrays of gullies often start from the same elevation on a slope, and melting of snow deposited on a steep slope.
The most enigmatic gullies are those found on Russell crater, which exist on the surface of sand-dunes and do not terminate in fan. Although these may indicate that gullies on Russell crater have experienced formational process not typical for other gullies in different regions, a significant merit for studying these gullies exist; actual growths of gullies on Russell crater are clearly observed in High Resolution Imaging Experiment (HiRISE) images. Therefore, we can measure the dimensions of the newly-developed gullies as well as estimate the growth rate, which are useful to constrain the possible range of rheological properties.
The growth rate of a newly-developed gully is estimated by comparing two images that cover the same region with different acquisition dates. The length of a ~2m wide incised gully channel grew about 50m between 2007/3/10 (PSP_002904_1255) and 2007/4/12 (PSP_003326_1255), and ~120m between 2009/1/14 (ESP_011580_1255) and 2009/3/5 (ESP_012213_1255). These show that the growth rate of gullies on Russell crater is at least faster than 2 m/day. Previously, two possible formational processes are proposed for gullies on dunes; (1) Relatively low-viscosity flow, which probably contains large-amount of liquid water, and (2) Relatively high-viscosity flow containing ice. We perform numerical simulations of Bingham fluids and find that, in general, the former is more consistent with our observation. Our preliminary results indicate that ~100 m^3 water, probably melted from ice in the upper part of the pre-existing gully, flow with sand grains that make up the dune, forming slurries with the viscosity of ~10^2 Pa s and the yield strength of ~10^2 Pa. These slurries flow likely migrate at the velocity of ~m/s. Thus, the formation of a newly-discovered part of the gully takes only about several tens of seconds to several minutes, which is consistent with observations. In summary, our results favor liquid-water origin for the formation of gullies on sand dunes in the Russell crater.

Keywords: Mars, gully, Russell crater