RECENT MARS: WET OR DRY OR ICY? C. M. Dundas[1], A. S. McEwen[2], and S. Byrne[2], [1]U.S. Geological Survey, Astrogeology Science Center, 2255 N. Gemini Dr., Flagstaff, AZ 86001, USA, [2]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA.

Introduction: Liquid water is central to life as we know it. Therefore, the presence of liquid water or ice on Mars is fundamental to understanding its habitability and to identifying Special Regions [1]. Evidence for significant volumes of current or recent liquid water is largely geomorphic, particularly gullies [2] and Recurring Slope Lineae (RSL) [3]. However, generating such volumes on Mars poses fundamental problems: Mars has a cold climate, low insolation, and low atmospheric pressure that make melting very difficult [4,5]. Mars is tens of °C colder and orders of magnitude drier than upland Antarctic climates, where there is minimal liquid water [6] and very limited biological activity [7]. Here we summarize several lines of evidence from the High Resolution Imaging Science Experiment (HiRISE) suggesting that Mars has widespread ice but little or no liquid water.

Observations: *Ice-exposing impacts:* Hundreds of new impact craters have been detected on Mars [8]. In the mid-latitudes, these impacts may expose ice [9,10]. HiRISE has now imaged 45 impact sites interpreted to have definite or probable exposures of ground ice. These enable mapping of the distribution of subsurface ice, although pore-filling ice may go undetected, and have demonstrated the presence of ice down to 39°N latitude. This distribution suggests a long-term mean humidity somewhat higher than present, or some equivalent effect on ice stability [10]. The exposed ice remains bright for months or years, indicating that it has a low regolith content [11]. Melting and freezing during impact might produce some clean ice but much is likely present in situ in the subsurface.

Gullies: Martian gullies resemble terrestrial features formed by liquid water and have been proposed to indicate groundwater release [e.g., 2], or snowmelt during high-obliquity epochs [e.g., 12]. Monitoring with HiRISE has shown activity in dozens of gullies, including channel erosion, new lobate debris-flow-like features, and development and migration of sinuous curves [13–15]. The activity correlates with the presence of CO_2 frost. H_2O frost may play a minor role [16], but not via melting. This extensive activity appears capable of forming gullies without aqueous processes. Melting in a past high-obliquity climate cannot currently be ruled out, and might be less challenging than at present due to a higher atmospheric pressure [17], but is not necessary to explain gullies.

Recurring Slope Lineae: RSL are warm-season flows, darker than their surroundings, that grow on steep rocky slopes. Initial hypotheses for RSL formation focused on possible liquid water due to the temperature dependence and similarity to seepage features on Earth, but acknowledged the possibility of unusual dry flows [3]. In light of the difficulties posed by all hypotheses for the formation of liquid water, we have given more detailed consideration to dry hypotheses. A key finding is that RSL terminate on slopes identical to the lee sides of Martian aeolian dunes, at the angle of repose for unconsolidated sand [18]. This suggests that RSL are dry granular flows, although H_2O might be involved in their initiation in some way.

Discussion: These lines of evidence are all consistent with a modern Mars where H_2O is dynamic and moves across the planet in response to a varying climate, but as vapor and ice. Gullies are consistent with formation by CO_2 alone and RSL with formation by dry granular flow. Deliquescence may produce traces of liquid [4,5,19] but these are probably very volumetrically limited because of the low water abundance in the atmosphere. Consistent with the challenges for life in the coldest, driest places on Earth [7], this model for Mars suggests little or no available liquid water and a low potential for extant near-surface life resembling terrestrial biota, and inhospitable conditions for microorganisms from Earth that might reach the surface.

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