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THERMODYNAMICS AS TOOL TO IDENTIFY WHERE AND WHEN TO SEARCH FOR PURE LIQUID WATER ON MARS

Abstract

The search for extraterrestrial life (ancient or living) is tightly coupled with the search for water in our Solar System. During the past 5 years, the scientific community has been notably prolific in publishing results that interpret data gathered *in-situ* by autonomous robots and by remote sensing as evidence of the existence of liquid water on Mars. One such example, was the observation of recurring slope lineae (RSL) attributed to seasonal freeze-thaw cycles of naturally occurring brine on the slopes of craters [1]. However, these same RSL have later been re-interpreted as dark slope streaks attributed to “avalanches” of fine grains, not to the flow of brine solutions [2].

The Martian atmosphere is not favorable to liquid water existing in a stable liquid state: the surface temperature varies between 10 and -90 C daily, the surface pressure varies between 600 and 1000 Pa, and the surface relative humidity can be between 10 and 75%. Precise atmospheric conditions can differ from the above values. With such low temperatures, pressures, and relative humidities, any pure water on Mars would either have to exist as a vapor or a solid.

However, classical thermodynamics predicts that impurities added to the water ice would result in a phenomena known as the freezing point depression, potentially allowing liquid aqueous solutions (*i.e.* brines) to exist on the Martian surface. This has been the primary avenue taken by scientists to search for liquid water on Mars and to (mis)interpret the RSL as brines.

Here, another idea (borrowed from the unconventional shale gas/oil industry of North America) is used to determine under what conditions, where and when one would potentially find pure liquid water on Mars. Using published data about the atmospheric conditions that exist on the Martian surface, we use classical thermodynamics to calculate the pore geometry needed for water to condense as a liquid. As far as we know, this is the first work considering nanoscale geological effects on the possibility of finding pure liquid water on Mars.

The calculated pore geometry and condensate contact angle place constraints on the requisite Martian soil/rock physical and chemical characteristics, thus allowing us to identify potential locations where one would expect to find pure liquid water on Mars. We present a candidate mission area and window for *in-situ* water prospecting on Mars.

[1] Nat. Geo. (2014) 7, 53–58.
[2] Nat. Geo. (2017) 10, 270–273.