CORRELATION OF SUBSURFACE ICE CONTENT AND GULLY LOCATIONS ON MARS: TESTING THE SHALLOW AQUIFER THEORY OF GULLY FORMATION.  S. J. Edlund and J. L. Heldmann. 1, Luleå University of Technology, Luleå, Sweden, jeanette.edlund@gmail.com , 2NASA Ames Research Center, Moffett Field, CA, USA, jheldmann@mail.arc.nasa.gov

Introduction: Images from the Mars Orbiter Camera on the Mars Global Surveyor show gully features resembling water-carved gullies on Earth. Geomorphic evidence suggests that the gullies were formed within the past few million years by fluvial activity [1]. One theory of gully formation contends that the source of the water feeding the gullies is a shallow liquid water aquifer. This theory requires a relatively dry overburden to maintain liquid water at the observed alcove base depths [2, 3]. We quantitatively test the shallow aquifer theory by calculating the temperature and pressure of the Martian subsurface at the measured alcove base depths using measured Gamma Ray Spectrometer (GRS) ice contents to determine if liquid water can exist at these locations.

Methodology: We calculate the thermal conductivity and density of the regolith overlying the hypothesized liquid aquifers by assuming an overburden ice content consistent with that measured by the Gamma Ray Spectrometer (GRS) at each gully site. We then calculate subsurface temperature and pressure fields based on this data to determine if liquid water can exist at the gully sites. Gully sites were identified in previous works for both the southern [2] and northern hemispheres on Mars [4].

The density and the thermal conductivity of the soil affect the calculated pressure and temperature at different depths in the Martian soil. Since the density and thermal conductivity of the soil is dependent on the amount of ice in the soil, the ice-to-soil ratio is a very important factor. This factor can be determined using the GRS data from the Mars Odyssey spacecraft. The ice concentration between -45° and +45° of latitude are assumed to be zero since ice cannot be stable there. Instead the hydrogen signature measured by GRS is assumed to come from hydrated minerals [5]. The measurements above the latitude of 60° are not accurate since a polar cap was present at the time of these measurements. Therefore we only analyze gullies between 60°S-60°N.

Results: Fifty-nine percent of the gullies fall outside of the temperature and pressure regime of liquid water at the alcove base depth when assuming an overburden consistent with the observed GRS ice content. However, it may be unrealistic to assume that the measured GRS ice content extends down to the depth of the gully alcoves. We therefore estimate the thickness of a dry layer that must exist within the overburden column for the water to be liquid at the alcove base depth. These calculations assume that the soil has a fraction of overburden with dry and icy components where the icy layer has the same concentration of ice as measured by GRS. We calculated the thickness of the required dry layer vs. the measured alcove base depth using the multi layer system. According to these calculations, liquid water could exist in approximately 81% of the gully locations.

The remaining 19% of the gully locations could not have liquid water at the depth of the alcove base because the required thickness of the dry layer exceeds the alcove base depth. We didn’t find any outstanding characteristics for the albedo, elevation, channel length or thermal inertia for the gullies where liquid water cannot exist in the subsurface aquifer compared with the other gullies where liquid water could exist in the subsurface aquifer. However, the 19% of gullies which cannot support a shallow liquid water aquifer according to these calculations had very shallow alcove bases.

It is possible that the gullies that could not have liquid water at the alcove base depth have been formed in a different way than the other gullies such as melting ground ice [6, 7], snowmelt [8] or a deep aquifer source [9]. Additionally, the resolution of GRS is on the order of several hundred km, which is much larger than the scale of the gully formations. Hence the GRS measurement may not be precisely indicative of the subsurface ice content at the exact location of the gullies.

References: