MISIP-2024 Project-1 – Project 1: Rheological measurements of Martian slurries

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Mars is certainly the most studied body of our Solar System aside from Earth. The amount of data available about its surface and its interior is extremely wide and, in most cases, extremely accurate. However, very specific and precise data about its surface composition is available only for very restricted areas where landers have been sent, and often times Remote Sensing data (e.g. CRISM) doesn't give back accurate values due to interferences from the atmosphere or Martian dust that may alter the values read by the instrument.
Therefore, indirect methods of measuring Martian surficial mineral composition are extremely important and valuable to obtain data that can be compared with different datasets and provide a good measure of the goodness of the parameters used in research.
In our study, we ran several rheological measurements on Martian simulants (MGS-1, MGS-1C, MGS-1S and mixtures of MGS-1 and MGS-1C) so that we could understand the response of Martian surface to the varying of several parameters. In the specific, we observed the changes occurring in the samples when varying the water content (and therefore the solid fraction), the Temperature, the salinity and when applying an oscillatory motion resembling tectonic movements.
Our analysis focused on Yield Stress and Viscosity analysis, and we found that they both increase exponentially when increasing the solid fraction of the samples, while they both increase at a slow rate when decreasing its Temperature. As for the salinity content, we ran rheological measurements using brines with varying molar fractions of $MgCl_2$, $CaCl_2$ and NaCl but with the amount of data we obtained, we couldn't find a definite relationship between molar fractions and rheological parameters (Yield Stress and Viscosity), except for the case of NaCl that showed a slight linear decrease in such parameters when increasing the Molar fraction of the chloride in the brine.
Lastly, we ran an oscillatory test to evaluate the sensitivity of such samples to seismic movements, and we found that the samples are relatively resistant to liquefaction as by varying the solid fraction at a T of 20°C, the Crossover Strain % settles at around 10%, a value that is above the accepted values for Martian geological activity and that allowed us to rule out this component as impactful in computational models of debris flow.
Once these values were obtained, we compared our results with Yield Stress and Viscosity values obtained by Naruse et al. in 2016 from inverse modelling of a lobate deposit in Protonilus Mensae. We found a very good match for the yield stress value of a sample composed of 20% Smectite and 80% MGS-1 simulant, but the viscosity values for this sample were quite far apart. This suggested that further experiments varying salinity and T conditions of the simulant are required to fully understand the composition and conditions of Martian surface in that location.
Thanks to our data and the comparison with the data gathered by Mangold et al. in 2003, we were also able to determine that there is a very high probability that clays are a significant component of Martian most surficial layers as all of our measurements of Yield Stress and Viscosity run on samples containing such component fell within the range that have been highlighted as most representative of Martian surface.

Even though this work did not succeed in finding the surficial composition of Martian terrain in the selected area, it highlighted a very promising experimental method to obtain such data in future studies.