Thermal Inertia of Sand at Different Levels of Water Saturation

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Introduction: As far as we know, life cannot exist without water. Therefore, whenever we encounter a new environment, specifically having to do with other planets, one of our first objectives is searching for this vital resource. That's why in 1965, when scientists obtained the first close-up picture of Mars, this became a phenomenon [1]. Scientists have already done the unexpected, proof that water exists on Mars. Even though it is almost exclusively frozen water, it is still proof that the Red Planet has the potential to support life. There has to be another way of knowing, not if there's water on Mars, but where and how deep. A prospective way is using satellites we already have orbiting Mars, like THEMIS or CRISM. If we are able to model how different sediments behave in different levels of saturation we can use the data to predict the location of water on the red planet and how deep the water source is.

Thermal inertia represents the ability of a material to store and conduct heat and is influenced significantly by the presence of water. [1]

The sediments found on Earth have been parallel to the sediments found on Mars, and due to this we are able to proceed with finding the behavior of sediments on Mars. This will allow us to accurately model from what we can conclude based on our research (on Earth).

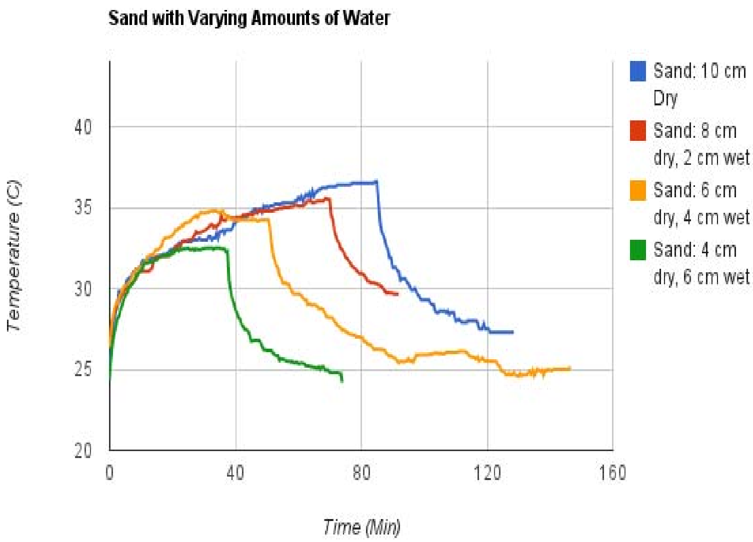
Method: The sediments we used were collected from the Eno River in Durham, North Carolina. After collecting a variety of sediments, we sieved the sediments to separate in two groups of grain sizes: fine grain (sand) and coarse grain (gravel).

The group that I was a part of tested sand. To avoid the sand from being saturated already, the sand was put into an oven to evaporate any water. Then, it was left to cool to avoid a skewing in the thermal properties. Each sediment group was placed into a bucket 10 centimeters tall and 20 centimeters wide to follow the NASA 10 centimeter rule, which states that all geological experiments must use a sample of sediment with these dimensions. For our heating source, we used heat lamps with light bulbs that are approximately 630 watts per square meter of light. These bulbs provide a wider range of electromagnetic energy and also include infrared and ultraviolet radiation in addition to visible light. This improves our model because this better simulates the nature of sunlight on Mars, which is approximately 590 watts per square meters of light. We conducted one test run outside, but there were too many variables that we could not control, so we decided that we would conduct all of our research indoors under the heat lamps. We set the heat lamps about 50 centimeters from the ground and 10 degrees from the sediment. We did not want to position the lamp directly over the sediment because that is not how it is on Mars or on Earth for that matter, only in certain places over certain times of the year. The next step was to set up the infrared thermometers. The thermometers were half a meter away from the sample and were facing 90 degrees from the sample.

In the beginning of the experiment, we conducted dry runs. We took three initial readings, taken thirty seconds apart from each other to make sure the thermometers were working properly. After the three initial readings, we turned the lamp on and began taking measurements of the sand's heating patterns every thirty seconds until the readings began to stabilize (this state was defined as when there were 10 readings that are within 1 degree C). We continued to take readings of the sand's cooling patterns until the sand had stabilized. After several days, we introduced our variable: water. Measuring from the bottom up, we saturated 2, 4, and 6 cm, each time covering the saturated

sand with more dry sand, then saturating again. Our definition of saturation was covering the sediment with enough water that a miniscule pool of water remains on the surface. There were thermal probes at 0, 5, and 7 cm, as well as on the surface to measure the heating and cooling patterns, but unfortunately, probe data produced spurious results.

Results:
Figure 1: *Dry control (blue), 2 cm wet (red), 4 cm wet (yellow), 6 cm wet (green).*



This graph represents the sand's heating and cooling curves. We modeled this graph with a piecewise function. This piecewise function would best fit the data if it was comprised of the natural log and the inverse exponential function. What we noticed was that the heat capacity, or the thermal inertia, was reduced under more levels of saturation, meaning the more saturated sand there was, the shorter time it took to stabilize. This is because one of water's unique properties is that it has a high specific heat, which makes it harder to reach a higher temperature. The control however, took the longest to stabilize but reached the highest temperature. Therefore, in thermal imaging such as that taken by THEMIS, these areas would show up cooler than their surroundings during the day and consequently warmer during the nighttime on Mars. In this way, thermal imaging could aid in the discovery of subterranean pockets of water on Mars.

Future Study: If we can continue to carry out this research, we may have answers that will open many doors to the scientific world. If we were to continue this experiment, we would perfect the thermal probes, because then we can accurately model the behavior of sand under saturation. More data would have made our experiment more meaningful. This would have been provided by the probes. Unfortunately however, their malfunctioning made the data unusable.

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References: [1] *The Mars Exploration Program. NASA, Gov.*