MARS SOCIETY
UNIVERSITY ROVER CHALLENGE, UTAH 2017

ITU ROVER TEAM SCIENCE PLAN

Organization Chart

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Aeronautical Engineering '19
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Geological Engineering '18
Tectonics, Astrobiology,
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1. Mars Science

Geology: The primary rock type on the surface of Mars is tholeitic-basalt, a fine-grained igneous rock made up mostly of the mafic silicate minerals olivine, pyroxene, and plagioclase feldspar [1]. When exposed to water and atmospheric gases, these minerals chemically weather into new minerals. Examples of hydrated minerals include the iron hydroxide such as hematite which gives the surface its red color; the evaporate minerals gypsum and kieserite; opalline silica; and phyllosilicates, such as kaolinite and montmorillonite [2]. The geomorphological indicators provide strong evidence for the presence of liquid water at the surface and the crust at various times in Mars's history. Besides, the Mars's volcano Olympus Mons is the largest known volcano in the solar system [3]. The polar caps of Mars, are mostly made of frozen carbon dioxide and water ice. Data collected has indicated that amount of water that is locked up at Mars' South Pole is enough to cover the planet in a liquid layer 11 meters deep [4].

Atmosphere: The Mars has a thin, dusty atmosphere. Surface temperatures vary between +20 and -85°C. The atmospheric pressure is too low to allow for the presence of liquid water on the surface. The Martian atmosphere is mostly composed of carbon dioxide. In its early history, Mars must have had a denser atmosphere; it was warmer on its surface, and liquid water was existed. The surface and atmosphere of the Mars are too cold for liquid water, therefore the water is not stable on the surface of Mars today. Water presents at Mars surface as ice at the polar caps and vapor in the atmosphere. Methane in the Martian atmosphere has 300-600 years lifetime, so it has been produced after the planets formed. Explanation for the methane can be come from either biological or geological origin [5].

Chemistry: Energy released from reactions between water and rock was more likely to have been the driving force for the first life. Chemical energy could be used to create complex molecules, stirring them together into complicating structures and supporting the metabolism of primitive organism. In the presence of prebiotic bacteria, all reactions end up with the product as carbon dioxide and that shows investigated area is watery, pH is suitable for life [6].

On the surface of Mars, three main compound groups are detected that, silicate, metal- sulfite melting and lithophile elements (Mg, Al, U,Th) [7] [8].

Moreover, in 1996 McKay and his team discovered PAH (polycyclic aromatic hydrocarbons) and carbonate nodules which they could be remains from microfossils [9].

In June, 2008, the Phoenix Lander returned data showing Martian soil to be slightly alkaline and containing vital nutrients such as magnesium, sodium, potassium and chloride, all of which are necessary for living organisms to grow [10]. Scientists compared the soil near Mars' North Pole to that of backyard gardens on Earth, and concluded that it could be suitable for growth of plants. Discovered traces of the salt perchlorate, while also confirming many scientists' theories that the Martian surface was considerably basic, measuring at 8.3 [11].

Surface Radiation: There are two reasons make the radiation of Mars stronger than on Earth. One, since there is no dense core at the center of the planet, magnetic field is not present for Mars and the atmosphere is very light, cannot provide enough protection for life on the surface [12].

[1] Soderblom, L.A.; Bell, J.F. (2008). "Exploration of the Martian Surface: 1992–2007". In Bell, J.F. The Martian Surface: Composition, Mineralogy, and Physical Properties. Cambridge University Press. pp. 3–19.

[2] Ming, D.W.; Morris, R.V.; Clark, R.C. (2008). "Aqueous Alteration on Mars". In Bell, J.F. The Martian Surface: Composition, Mineralogy, and Physical Properties. Cambridge University Press. pp. 519–540.

[3] https://mars.jpl.nasa.gov/gallery/atlas/olympus-mons.html,

[4] http://www.daviddarling.info/encyclopedia/M/Marspoles.html

[5] http://exploration.esa.int/mars/46038-methane-on-mars/

[6] Sullivan, W. T., & Baross, J. A. (2007). Planets and life: the emerging science of astrobiology. Cambridge: Cambridge University Press. Chapter 18 Mars

[7] Shaw, A. M. (2006). Astrochemistry: from astronomy to astrobiology. West Sussex, England: Wiley

[8] Carr, M. H. (2008). The Surface of Mars. Cambridge: Cambridge University Press.

[9] Forget, F., Costard, F., & Lognonné, P. (2008). Planet Mars: story of another world. Berlin: Springer.

[10] Martian soil 'could support life' (2008, June 27). Retrieved May 1, 2017 from http://news.bbc.co.uk/2/hi/science/nature/7477310.stm

[11] Chang, Alicia (2008-08-05). "Scientists: Salt in Mars soil not bad for life". USA Today. Associated Press. Retrieved May 7, 2017

[12] http://www.sci-news.com/space/science-mars-radiation-measurements-surface-01629.html

2. Background Research

2.1. Articles and Books

Figure 1: Rock sampling from sedimantary outcrop

Carol R. Stoker, Jonathan Clarke, Susana O.L. (2011). Mineralogical, chemical, organic and microbial properties of subsurface soil cores from Mars Desert Research Station (Utah, USA): Phyllosilicate and sulfate analogues to Mars mission landing sites. Cambridge: Cambridge University College.

Soderblom, L.A.; Bell, J.F. (2008). "Exploration of the Martian Surface: 1992–2007". In Bell, J.F. *The Martian Surface:* Ming, D.W.; Morris, R.V.; Clark, R.C. (2008). "Aqueous Alteration on Mars". In Bell, J.F. *The Martian Surface: Composition, Mineralogy, and Physical Properties*. Cambridge University Press.

Lakes on Mars - Nathale A.

Water on Mars and Life - Tetsuya Tokano

2.2. Collaborated Events

Figure 2: TOC titration experiment

Observation of microbiological life at Medical Faculty Microbiology and Virology Laboratory, IU.

Measurements of total organic carbon, EMCOL, ITU.

Planetary climate research at Eurasian Institute of Earth Sciences, ITU.

2.3. Experts Consulted

James W. Head III, Prof. Department of Earth, Environmental and Planetary Sciences, Brown University, USA

Giulia-Bongiorno, Department of Environmental Sciences, Sub-department of Soil Quality, Wageningen University and Research, Netherlands

Kadir Kursat Eris, Eurasia Mediterranean Center of Oceanography and Limnology, Turkey

Mehmet Sakinc, Prof. Eurasia Institute of Earth Sciences, Istanbul Technical University

Nurgul Balci, Assoc. Prof., Geomicrobiology, Biogeochemistry, Istanbul Technical University

Zerrin Aktas, Prof. Dr., Medical Microbiology, Medical Faculty, Istanbul University

Celal Sengor, Prof. Dr. hc, Eurasia Institute of Earth Sciences, Istanbul Technical University

2.4. Experiments Performed

Total Organic Carbon Analysis (Wayne Black Method): Organic carbon analysis in sediment via Wayne Black method. This experiment aims to identify organic based carbon amount in sediment by reaction by running oxidation and reduction reactions respectively.

Shimadzu TIC/TOC Analyzer: Total carbon analysis are based on the measurement of the amount of carbon dioxide generated by incineration at 900 ºC. This method have been found undesirable for the tasks due to challenges faced such as time and heating mechanism.

Potassium Permanganate Test: This method is also using reaction between potassium and free carbon. Yet, it is not efficient to classify the C whether if it is organic or inorganic.

3. Science Task Methods

3.1. Rover's Onboard Instrumentation

Atmospheric Pressure and Temperature Sensors: By indicating atmosphere pressure and temperature it would be possible to determine which forms water could be under such conditions.

Temperature and Soil Humidity Sensor: Due to low temperature and pressure values of Mars surface, it is more likely to find liquid water below the surface. That is why the rover will measure subsurface temperature. If there is microbial life in soils, most probably it is in humid soils. The rover will investigate soil humidity and this data will be used for deciding if the sample worth to be analyzed in the lab [1].

Methane Sensor: To find the possible locations for sampling, output of the methane sensor will be considered.

3.2 Sampling Mechanism

Samples will be collected via a scoop mechanism. The robotic arm will dig down until the 10 cm depth. Then the probe will be inserted to the ground to clarify the hospitality of the sampling site. When the readings are approved by the science team, the operators will continue to the digging process for the final excavation. The sterile air tight containers will be used onboard the rover for each sample. Rock samples will also be collected via same mechanism for mineral observation in the lab.

Figure 3: Scoop mechanism test

3.3. Visual Observation Tasks

Panoramic View: The wide-angle panorama of the site will be taken via 120° over-the-top camera of the rover.

Stratigraphic Profile: A stratigraphic profile photo of the surrounding hills will be taken by the rover cameras.

Sample Site Photographing: Sample sites will be photographed via the front camera under the robotic arm. The hole will be shown clearly.

3.4. Laboratory Tests

HCl Test: Carbonates are minerals that form at low temperature in the presence of water. HCl will be used to determine the presence of $CaCO_3$. If the sample contains $CaCO_3$, bubbling will be observed. This will prove presence of inorganic carbon and its past presence of water in the soil sample.

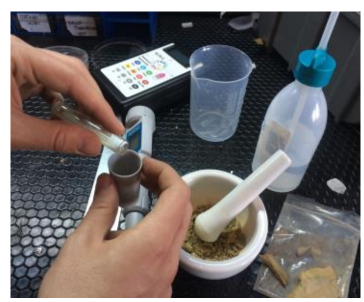

Figure 4: TDS measurement

Microscope (AM Scope B120C): Laboratory crew will investigate presence of bacteria with microscope in order to find the evidence for life.

Soil pH: Soil pH is a basic soil property that affects many chemical and biological activities in the soil. Solubility of many nutrients is low on alkaline soil [2]. We will measure soil pH via our KMoon soil tester device.

Optical Spectroscopy: The spectra of the samples will be acquired via ALTA II visible light reflectance spectrometer. The sample will be categorized according to spectra database of ours on MatLab.

Organic Carbon experiment: In order to analyze organic carbon amount in soil sample, Wayne Blank back titration method is chosen due to its accuracy.

TDS Test: We will use Kmoon soil tester device to measure Total Dissolved Solid (TDS). Electric conductivity of the sample would be calculated from the data.

[1] [Mars, Water and Life. (n.d.). Retrieved from https://mars.jpl.nasa.gov/msp98/why.html]
[2] http://www.agvise.com/educational-articles/soil-ph-a-basic-soil-property/

4. Mars Missions and Instrumentation

4.1. Viking Mission

Viking landers could not provide any strong evidence of life near the landing site. The landers' gas chromatograph/mass spectrometer instruments found no sign of organic chemistry. The X-ray fluorescence spectrometer instrument analyzed elemental composition of the regolith. In addition, the probes provided detailed sensory data from the surface [1]. Dust storms, unstable pressure values, and transport of atmospheric gases between the polar caps were observed [2].
Since GC/MS were used together, its sensitivity was increased that could detect all gas molecules, which have two carbon molecules at least, and probe sensors identified organic molecules. However, it was not obvious if these molecules were belong to a living bacteria colony or a sediment.
The Viking mission were failed aspect of finding living organisms because of Mars surface is covered by iron oxide compounds and peroxide compounds. Since these compounds are highly reactive with water and they ended up with the product of oxygen, upper layer of Martian soil was not suitable for living. Also, chemosynthesis reactions are more common rather than biosynthesis reactions. On the surface of Mars there were rocks like on Earth which were clay-like rocks and suitable for living [3].

4.2. Phoenix Mission

Phoenix searches for Martian arctic support life, history of water at the landing site, and how is the Martian climate affected by polar dynamics.
In its instrumentation method; a robust robotic arm digs through the soil to the water ice layer underneath, and delivers soil and ice samples to the mission's experiments; miniature ovens are used for chemical analysis of trace matter and a mass spectrometer are used and chemistry lab-in-a-box, assembled by JPL, characterizes the soil and ice chemistry [4].

4.3. Mars Science Laboratory Mission

Identifying whether if Mars ever was habitable for microbial life, is Mars Science Laboratory's primary mission. In order to understand this, the rover analyzes Mars soil and rocks, Mars climate, Mars geology, signs of water and organic compounds which are building blocks of life [5]. At Gale Crater, biochemically usable nitrogen is found. Due to nitrate has three oxygen bounding as structure NO is product of decomposed nitrate [6].
Tunable laser spectrometer is used in order to detect water vapor and methane in gas form. This carbon identification project aims to there was a life process in the Mars history [7].
Wet-Chemistry experiment, that is an onboard experiment, aims to identify sulfur based gas molecules by pouring N-methyl-N-tert-butyldimethylsilyl-trifluoroacetamide in to drill exit and observing chemical bonding breakages [8].

MSL Instrumentation

Cameras: Mast Camera (Mastcam), Mars Hand Lens Imager (MAHLI), Mars Descent Imager (MARDI). **Spectrometers:** Alpha Particle X-Ray Spectrometer (APXS), Chemistry & Camera (ChemCam), Chemistry & Mineralogy X-Ray Diffraction/X-Ray Fluorescence Instrument (CheMin), Sample Analysis at Mars (SAM) Instrument Suite. **Radiation Detectors:** Radiation Assessment Detector (RAD), Dynamic Albedo of Neutrons (DAN). **Environmental Sensors:** Rover Environmental Monitoring Station (REMS). **Atmospheric Sensors:** Mars Science Laboratory Entry Descent and Landing Instrument (MEDLI) [9].
In additional to these missions; Sojourner (1996), Spirit (2003), Opportunity (2003), Phoenix (2007) missions also landed on the Martian surface successfully, but their main focus was not astrobiology [5].

[1] https://www.jpl.nasa.gov/news/fact_sheets/viking.pdf
[2] https://nssdc.gsfc.nasa.gov/planetary/viking.html
[3] Planel, H. (2004). Space and life: an introduction to space biology and medicine. Boca Raton (Fla.): CRC Press.
[4] http://phoenix.lpl.arizona.edu/mission.php
[5] [http://mars.nasa.gov/msl/news/pdfs/MSLLanding.pdf] http://mars.nasa.gov/programmissions/science/
[6] https://www.jpl.nasa.gov/news/news.php?feature=4516
[7] https://mars.nasa.gov/msl/mission/instruments/spectrometers/sam/
[8] http://www.space.com/28869-curiosity-rover-mars-wet-chemistry-organics.html
[9] https://mars.nasa.gov/msl/mission/instruments/