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Statement of
Dr. Luther Beegle
Principal Investigator, SHERLOC on Mars 2020
Principal Scientist
Jet Propulsion Laboratory

before the

Subcommittee on Space and Aeronautics
Committee on Science, Space, and Technology
U. S. House of Representatives

Chairman Beyer, Ranking Member Babin, and members of the Subcommittee, I am honored to appear before this Subcommittee on behalf of the California Institute of Technology to discuss the Mars Perseverance Mission.

The Mars 2020/Perseverance Mission

On February 18, 2021, the Perseverance rover touched down in Mars' Jezero Crater. Roughly 3.5 billion years ago, Jezero Crater was the site of an ancient lake. Rivers flowed both into and out of its basin over an extended period of time. Orbital imagery shows that Perseverance has in fact landed right in front of what was once a river delta. Places like this can concentrate biological activity and are known to be an excellent source of preservation of organic molecules, and we have high hopes for what this location may hold for science.

The Mars 2020 mission has four science goals: 1) Explore an ancient Martian environment of astrobiological relevance and decipher its geological processes and history, including past habitability; 2) Assess the biosignature preservation potential within that geological environment and search for them; 3) Make progress toward returning scientifically selected, well-documented samples from Mars to Earth; and 4) Provide an opportunity to contribute to future human missions to Mars.

Of course, inspiration is always part of the mission. Perseverance has captured the public's excitement and imagination through the images returned from the surface; the incredible videos of the entry, descent and landing phase; and, most recently, the highly anticipated flight of the Ingenuity helicopter. And we are only 68 sols, or Martian days, into our mission.

The Mars 2020 science team consists of nearly 500 individual researchers with experiences and backgrounds that range from undergraduate students to University professors to NASA Jet Propulsion Laboratory (JPL) experts who have worked every Mars rover mission since Mars Pathfinder/Sojourner in 1997. They have diverse scientific backgrounds in disciplines such as geology, climate, biology, and planetary science. It really is an amazing team and I am honored to be part of it.

Scientific Background

All evidence points to Mars being more Earth-like in its early history, with rivers, lakes, and a large ocean potentially filling its northern hemisphere. At roughly the same time when life was starting on Earth, water also flowed across the surface of Mars. We believe that many of the same conditions we think would be required for life on Earth were present on Mars, including a chemical energy source and access to organic carbon.

On Earth, many things have changed since life began several billion years ago. Key clues to the origin of life on our planet have largely been erased by weathering, erosion, and plate tectonics. On Mars, by contrast, there is little evidence of plate tectonics and the surface has been less affected by these other processes. Thus, Mars has a much better-preserved ancient rock record. Most rocks on the surface are thought to have been formed when Mars was warmer and wetter than we find it today. Rocks on Mars could preserve key evidence of planetary formation, clues to its habitability when liquid water was present, and, potentially, signs of microscopic life.

Today, Earth is the one and only planet where we have evidence of life's origin. From a scientific perspective, if we find that life originated on Mars, this raises the possibility that life could be abundant in the universe. Conversely, if we find the opposite, we might be able to better constrain the requirements for the origin of life and better explain how life originates on a planet. From a philosophical perspective, if life is plentiful in the universe, it might bring us new perspectives on ourselves and the universe. If life is rare, we might start to realize how unique and precious life is on Earth.

Building Instruments to Find Life

In order for any new instrument to be incorporated into a payload, it has to demonstrate scientific utility and technical feasibility. This process can take many years, decades even, and requires scientists and engineers to work together to generate an integrated and robust flyable concept. The development of an instrument concept is a process in which one experiences successes sprinkled with many rejections and failures. It also comes with no guarantee of ever getting a chance to fly on a mission.

Some astrobiology instrument concepts are not sensitive enough to detect the faint traces of life expected on Mars. Some concepts simply cannot function in the harsh and complex Martian environment. Finally, even with advances in technology, some concepts simply cannot be miniaturized to fit on a rover. There is no way to know at the beginning of development which concept will survive to flight. It is clear that it really does take perseverance to get to Mars.

SHERLOC

Perseverance's payload has seven instruments that will document the landing site and analyze samples for future return to Earth. I am the Principal Investigator for an instrument called SHERLOC, which stands for Scanning Habitable Environments with Raman & Luminescence for Organics & Chemicals. SHERLOC was developed to search for clues within an astrobiologically relevant environment on Mars. Starting soon, SHERLOC will work to identify habitable environments and see what we can deduce regarding Martian history. SHERLOC was selected through the 2013 announcement of opportunity for payload elements for the Mars 2020 rover. The proposal took a year to write and was one of seven selected from a pool of over 58 instrument concepts. The concept for SHERLOC was first conceived at JPL starting in 1998 and went through multiple stages of development until the flight unit was delivered in January of 2020.

SHERLOC enables high-sensitivity detection, characterization, and spatially-resolved correlation of trace organic material within Martian outcrops. SHERLOC can identify potential biosignatures in the Martian surface and near sub-surface. It does this by combining microscopic imaging with Raman and fluorescence spectroscopy to map a postage-stamp-sized Martian sample.

Two microscopic cameras, Autofocus and Context Imager, or ACI, and Wide Angle Topographic Sensor for Operations and eNgineering, or WATSON, obtain high-resolution images of the surface to identify textures and features smaller than 30 microns. Raman spectroscopy identifies organic, chemical, and mineral components present. Fluorescence spectroscopy detects and classifies organic molecules that have aromatic ring structures. It does so within a 100 micron-spot, roughly the same size as a human hair, that is moved over a surface. To assess the presence of potential biosignatures, SHERLOC makes mineral and organic maps. These are then analyzed by the science team to determine their astrobiological significance.

The Martian surface is an inhospitable place for most organic molecules due to high ultraviolet fluctuation and oxidizing conditions. Perseverance has an abrasion tool to get to the protected interior of a rock where organic molecules have been shown by NASA's Mars Science Laboratory/Curiosity to exist. The classes of organic material that SHERLOC is sensitive to include amino acids, nucleobases, and aromatic compounds. These molecules are found in life as we know it, but a number of these have also been found in meteorites or are known to be created though other abiotic chemical processes on the Earth. This is why we would call any findings by SHERLOC "potential biosignatures" rather than claiming to have an instrument capable of unambiguous life detection.

Minerals can also be a form of biosignature. Biology can create distinctive signatures that can be observed in assemblages of astrobiologically-relevant minerals (e.g., carbonates, nitrates, phosphates, sulfates). The presence of such assemblages of minerals in association with organics can be an important component in evaluating whether something may have been produced or brought about by biological processes. SHERLOC will be looking for these types of features.

As designed, SHERLOC specifically targets minerals and organics that are indicative of Jezero Crater's watery past. These minerals can also represent key sources and sinks for elemental cycling necessary for life. Life on Earth is driven by oxidation-reduction reactions and utilizes key elements such as carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur. The abundance and diversity of compounds containing these elements in a sedimentary environment are important measures of habitability.

Working Toward Sample Return

As hard as I and others have worked on SHERLOC, the rest of our instrument suite and other instruments working on the Martian surface, it is hard to identify instruments or measurements that could unambiguously identify life on a Martian sample at present. After all the work we have – and will – put into Perseverance, the best way to unambiguously determine whether life was ever present within Jezero Crater will still be to return samples to Earth. To that end, the Mars 2020 mission is designed to collect well-characterized samples that have high scientific value. When these samples are eventually returned to Earth, they will be analyzed by state-of-the-art instruments, some that cannot be flown to Mars. Some of these instruments have not even been invented yet. The combination of knowing where a sample came from and multiple lines of evidence within that sample should be able to get us closer to answering the tantalizing question of whether life exists, or ever existed, on the next planet out from the Sun.

Finally, I have given many talks at schools focusing on the Mars 2020 mission and SHERLOC in particular. I usually end those talks reminding the students that the samples that we are collecting will be arriving back on Earth in the 2030's. That by pursuing a career in science and engineering, they can help answer the questions that are currently waiting to answer. As we inspire this next generation of researchers, I imagine all the wonderful things we will be able to accomplish and all the big questions we will be able to answer.

I would be happy to answer any questions you may have.