Statement of
Dr. Tanja Bosak
Professor of Geobiology, Lead of the Program in Geology, Geochemistry and Geobiology,
Massachusetts Institute of Technology
Participating and Co-Lead on Returned Sample Science, Mars 2020 Perseverance rover mission

before the
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Committee on Science, Space and Technology
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What do Scientists Hope to Learn with NASA's Mars Perseverance Rover?

How, where and when life originated is one of humanity's great unsolved questions. Until now, we were only able to explore this question on our own planet, where the record of life before 3.5 billion years ago is absent. In contrast, Mars has preserved a rock record up to a billion years older than the oldest well-preserved rocks on Earth. Studying these rocks will enable us for the first time to probe the emergence of life on another planet. This is the goal of the Perseverance rover, which landed in Jezero crater on Mars. To achieve this, the mission aims to collect 30 samples of rocks and soils for future return to Earth as part of the international Mars Sample Return campaign. Scientists will then be able to analyze these samples in terrestrial laboratories. These will be the first set of samples from another planet that are relatable to specific locations and rocks or soils that formed in established sequences of geologic events. Just as the Apollo program did for the Moon, these samples will revolutionize our understanding of Mars science and stimulate enormous interest in science and technology for decades to come.

The scientific community identified many questions that can be addressed by studies of the returned samples. These include looking for past life, tracking changes of Mars's climate, atmosphere and habitability through time, establishing when rivers and lakes existed on the surface of Mars, determining how impacts and weathering affected the surface, and understanding the evolution of Mars's interior. Some of the returned samples will be collected in environments that were likely habitable during the time from which we have little record on Earth. Thus, for the first time ever, the scientific community will be able to look for the earliest stages of life by applying the criteria developed to investigate organic compounds and other potential signs of life in rocks from Earth. Analyses of returned samples can tell scientists what the earliest habitable environments looked like, whether early Mars received abundant building blocks for organic life from comets or asteroids, and whether some conditions at its surface enabled the synthesis of more complex organic compounds. Even more ambitiously, we can even ask whether any early life may have been transferred between Earth and Mars.

Following helicopter flights, the Perseverance rover will begin its traverse away from the landing site to explore an ancient lakebed inside the crater. During this traverse, the science team will acquire remote imaging, radar, and chemical data to characterize the geology of different regions at cm-to-km scales and establish the time sequence in which the rocks were deposited. Instruments on the rover's arm will also image the rocks at scales comparable to those shown by a hand lens, determine the composition of minerals, and look for potential signals of organic compounds in rocks. Samples judged to have the greatest potential for answering the key science questions will be collected, documented and cached for return to Earth. The selection of a returnable sample cache by the Perseverance rover team is critical for the success of the subsequent legs of the Mars Sample Return campaign. This requires the identification of samples that are most likely to preserve organic compounds under conditions that operated in habitable environments on early Mars.

On Earth, we can use a great diversity of instruments to determine the origin and ages of the samples, reconstruct past climate change, characterize organic matter and search for signatures of past life. Owing to the small size of collected samples, only small amounts of returned material will be available for analyses and most of these analyses will have to be performed at very small spatial scales, from nanometers to millimeters. These analyses can lead to a new understanding of the climate, the cycling of sediments, water, and inorganic and organic carbon on and within Mars. Any organic carbon present in the returned samples can also shed light on processes that control planetary habitability and lead to life. In the upcoming decades, the returned samples will likely stimulate new developments at the intersection of geology, geochemistry, geobiology, materials science, mass spectrometry, microscopy, spectroscopy, planetary science, chemistry, and astronomy.

I have always been interested in natural sciences, but growing up in Croatia as a first-generation college student, I never thought that I could one day be involved in the search for past life on Mars. Now, the weekly e-mails from school children and teachers, students, retired physicians, journalists and people with little-to-no background in science tell me that missions to Mars and sample return science resonate with people's innate curiosity. Scientists and non-scientists, in the US and abroad, want to know what samples from our closest planetary neighbor can tell us the earliest beginnings of life on Earth and humanity's place in the Universe.

Tanja Bosak was born in Croatia and graduated from the Zagreb University with a degree in Geophysics. After a summer of research at JPL, she moved to the California Institute of Technology in Pasadena, where she studied signatures of microbial processes in ancient sedimentary rocks and earned a Ph.D. in Geobiology. She spent two years at Harvard as a Microbial Initiative Postdoctoral Fellow, joined the Department of Earth, Atmospheric and Planetary Sciences at MIT in 2007 and is now a Professor of Geobiology and the group leader of the Program in Geology, Geochemistry and Geobiology.

Tanja's work integrates microbiology, sedimentology and stable isotope geochemistry into experimental geobiology to ask how microbial processes leave chemical, mineral and morphological signals in sedimentary rocks. Her lab uses this approach to explore modern biogeochemical and sedimentological processes, interpret the co-evolution of life and the environment during the first 80% of Earth history and look for signs of past life on Mars. For this work, and her work with graduate students and undergraduates, Bosak received the Subaru Outstanding Woman in Science award by the Geological Society of America (2007), the Macelwane Medal from the American Geophysical Union (2011), the Edgerton Award for young faculty at MIT (2012), the Undergraduate Research Opportunities for Undergraduates Mentor of the Year award by MIT (2012) and the Award for Outstanding Contributions and Dedication to Geobiology and Geomicrobiology from The Geobiology and Geomicrobiology Division of The Geological Society of America. Bosak is a fellow of the American Geophysical Union (2011), the American Academy of Microbiology (2021), and a subject editor for Geobiology, Frontiers of Microbiology and Geochemical Perspectives Letters.