SOIL SAMPLING WITH NANOSCALE VIBRATION SENSORS FOR ON-SITE DETECTION OF MICROORGANISMS J. C. Johnson[1,2,3], P. A. Johnson[1,3], and A. A. Mardon[2,3], [1]Faculty of Engineering, University of Alberta (email: jcj2@ualberta.ca), [2]Faculty of Medicine and Dentistry, University of Alberta (email: paj1@ualberta.ca) [3]Antarctic Institute of Canada (103, 11919-82 Str. NW, Edmonton, Alberta CANADA T5B 2W4; email: aamardon@yahoo.ca)

Introduction: The search for extant life has taken on several chemically-driven approaches to measure chemical signs of life. Unfortunately, this requires adequate knowledge of the metabolic pathways involved. Kasas *et al.* suggest we tap into another common signature of life – movement. This team has designed sensors to detect the nano-vibrations created by the metabolic activities of microorganisms. Here, we suggest a formal application of this device in soil sampling for the search for microbial life on Mars.

Current limitations for martian soil sampling: Soil sampling is a challenging endeavor in extraterrestrial scenarios; particularly, for the conditions of Mars.

Perchlorate concentrations: The high concentration of perchlorates in martian soil make detection of life-related organic molecules challenging.

Incompatibility of chemical methods: Historically, several forms of spectral techniques (fluorescence, gamma, Raman, etc.) have been developed in Mars Analog environments in order to search for microbial biomass in the martian regolith, rocks, ice, and permafrost. These techniques rely primarily on elemental composition analyses for identification of biomarkers that can discriminate the presence of microorganisms. One concern is that the use of Earth's signature of life criteria for Mars is limited.

Contamination and loss of sample integrity: Furthermore, there are several limitations associated with soil collection, containment, and transport. Firstly, the sample is not contaminated with any dust or biological material brought from Earth. Secondly, once the rover has obtained the samples, the soil is sealed in airtight capsules and launched, subjecting them to the forces and impacts associated with transport. Thirdly, following its arrival at Earth, samples are released for scientific analysis only if they are determined to be non-hazardous as per NASA guidelines. Lastly, it is important to realize that this process likely spans close to an year, meaning it could have effects on sample features that preclude it from being properly analyzed.

The design and implementation of nanoscale vibration sensors: One way to overcome these limitations is represented by a novel development in nanoscale vibration sensors. These sensors employ a cantilever to detect motion. The cantilever is comprised of an arm anchored at one end for structural support and functionally interacts with the specimen at the other. Inspired by the atomic force microscope that uses cantilever vibrations to image surface atoms, the sensor works on the assumption that microbes in the sample that are alive will predictably move, e.g. beat its cilia. The functional end has to be initialized with a linker molecule based off the level of specimen immobilization desired. For example, in bacteria, yeast, and plant cells, Kasas *et al*. chose glutaraldehyde while for neuron cells, they utilized poly-L-lysine.

Complementing these sensors with traditional Martian soil sampling, it is possible to avoid being solely reliant on chemical detection that could be irrelevant to extraterrestrial life. By combining dynamic with chemical information, we could achieve greater detail in the characterization of life. Additionally, we believe there exists potential for the sensor to be modified to provide on-site readings. By developing this technology for some added capabilities, we may be able to bypass soil mobilization procedures that lead to the loss of sample integrity.

Here, we propose a few amendments to the basic cantilever mechanism: 1) create a cantilever array that contains several different sensors paired with several different linker molecules; 2) incorporate a robotic appendage to facilitate sample loading; 3) adjust physical properties of the cantilever (i.e. spring constants) to match the gravitational field of Mars. In this way, we can assess for a breadth of microorganisms while enhancing effectiveness of soil data collection.

Conclusion: The search for extant life on Mars is intimately linked with building a better systems surrounding geographic surveillance and habitat scanning. Developing on-site mechanisms for detection of nanomotion can improve the efficiency with which we search for microorganisms.

References:

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