Optical microscopy and AFM as complimentary tools in detecting signs of life in ocean world analog samples

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Abstract

The search for extant life beyond earth remains at the core of the longstanding question "are we alone?" As habitable environments within the solar system are identified, exoplanets with Earth-like characteristics discovered, and the limits of life on Earth are redefined, excitement and interest grow to search for life elsewhere. With non-returning NASA missions planned for investigating the habitability of ocean worlds (e.g., Europa Clipper Flyby, Dragonfly mission to Titan) new in situ technologies are necessary to differentiate between biotic and abiotic micro to nano-scale particles and accurately define the properties of sampled material. Natural samples collected from a range of Earth's environments can provide useful analogs to ocean world-like systems and a convenient path to direct instrument development. One instrument in development at NASA AMES is the Europa Luminescence Microscope (ELM), which incorporates a filtering system and autonomous staining of specific bioindicator molecules which are detected with the microscope at ~micron resolution. Also in development, atomic force microscopy (AFM) is a potentially viable and sensitive technique for identifying physical signs of life. AFM has space-flight heritage in which it was used on two missions for particle (soil and dust) imaging (NASA's Phoenix Mars Lander and ESA's Rosetta Space Probe to Comet 67P). In this project, we have prepared six individual micron-scale particle types (three abiotic and three biotic), stained them for presence of DNA, and have performed optical microscopy observations and begun AFM measurements. We hypothesize that nanomechanical properties (i.e. stiffness, adhesion and energy dissipation) of biotic and abiotic particles will allow for distinguishing between a mixture of these particles, and further, the use of glacial ice from Antarctica as an ocean world analog sample will test the capability of these techniques for physical biosignature detection.