WATSON

Exploring Microbial Life in Subsurface Ice

A Wireline Ice Drill with Integrated Deep Ultraviolet Raman & Fluorescence Spectrometer for Subsurface Life Detection

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WATSON is a an instrument under development intended for ice borehole mapping and organic detection. WATSON is based on SHERLOC, the deep UV Raman and fluorescence spectrometer selected for Mars 2020 [1].

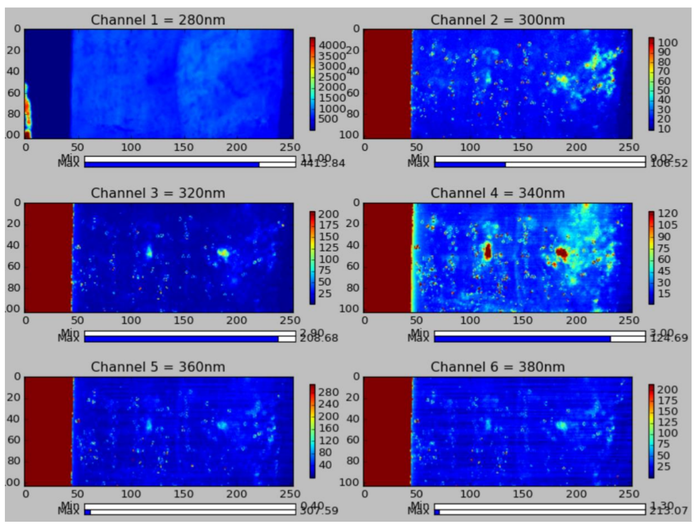
Layered ice deposits provide an environment where chemical and biological signatures can be preserved over geological timescales.

Greenland and Antarctica have been found to preserve organic material including active microbial communities [2]. In Greenland, at ice sheet margins, glacial (blue) ice is exposed. This allows In-situ organic and life-detection instruments to investigate the chemical environment while preserving the spatial context of deposition are needed to enable future missions to ocean worlds such as Europa and Enceladus.

Method of Detection

WATSON fuses deep UV Raman and fluorescence spectroscopy to detect spatially resolved organics in subsurface ice. The spectral analyses enable detection of C=C, C-H, and other CHNOPS containing compounds, and fluorescence characteristics of many aromatic-containing compounds. Context images allow correlation with visible textures and grains within the ice.

Benefits of deep UV excitation include a pre-resonance or resonance enhancement in some organics, and a Raman window below 270 nm, out of the fluorescence region [3, 4].

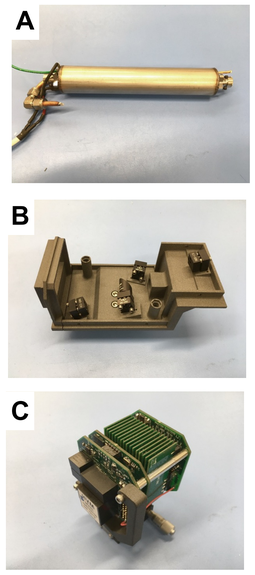


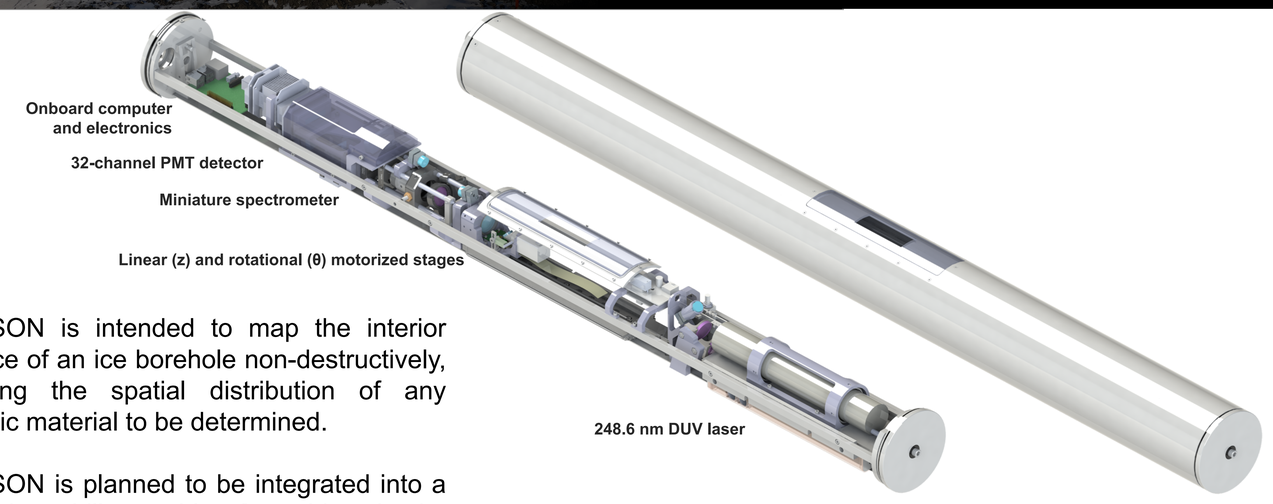
Fluorescence map of ice core from Lake Fryxell, Antarctica, showing fluorescence due to sediment inclusions with a peak emission around 340 nm. Data was obtained on a six channel PMT laboratory instrument.

Field Deployments

An initial field test in Kangerlussuaq, Greenland in March 2017 will provide an opportunity to test some of the spectroscopic components of the instrument and investigate the ice borehole.

2018/2019 deployments to Kangerlussuaq, Greenland will demonstrate operation of WATSON to a planned depth of 100 m.





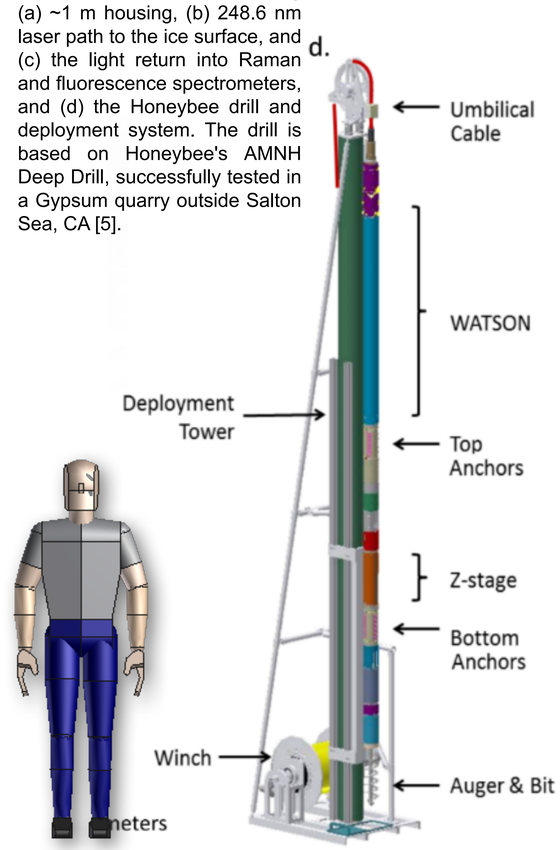
WATSON prototype for 2017 deployment. Left: (a) 248.6 nm DUV SHERLOC-heritage laser, (b) miniaturized fluorescence spectrometer, and (c) 32 channel PMT array detector

WATSON is intended to map the interior surface of an ice borehole non-destructively, allowing the spatial distribution of any organic material to be determined.

WATSON is planned to be integrated into a Honeybee drill, capable of reaching depths of 100 m.

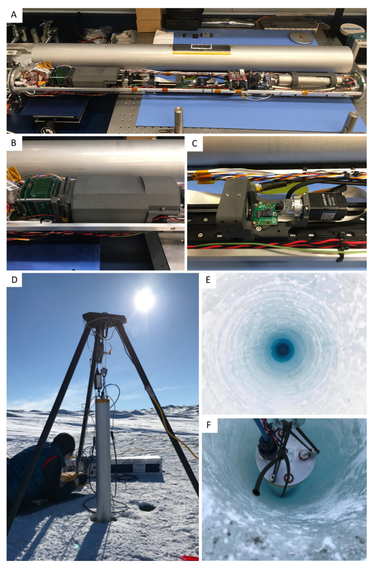
Drill & Deployment System

WATSON schematic showing (a) ~1 m housing, (b) 248.6 nm laser path to the ice surface, and (c) the light return into Raman and fluorescence spectrometers, and (d) the Honeybee drill and deployment system. The drill is based on Honeybee's AMNH Deep Drill, successfully tested in a Gypsum quarry outside Salton Sea, CA [5].

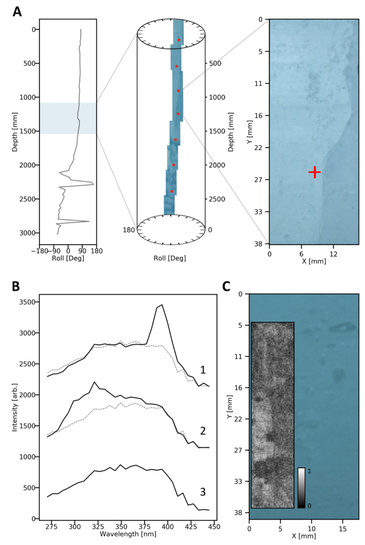


WATSON Science

- Detect and characterize organic compounds and potential biosignatures, including microbes, in subsurface ice environments, as well as determine their spatial distribution.
- In locations where layered ice forms a temporal record of organic deposits, understand whether analyses of a single site can provide information regarding organic content and distribution over geological timescales.



Images showing (a) WATSON and tube prior to deployment, (b) spectrometer and PMT array and detector electronics package, and (c) carriage with focusing optic, context camera, and rotational motor. Images (d) through (f) show WATSON deployed at Kangerlussuaq, Greenland, and the test site ice borehole with and without the instrument.



WATSON data products resulting from the two primary operational modes of the instrument. (A) extended borehole mapping: knowledge of the instrument position within the hole is provided by the surface winch and onboard roll sensors. Along with context imagery, these ancilliary data spatially locate spectral measurements, assembling a point cloud of spectral data. (B) depicts a typical spectra from the ice (3), along with two spectra with additional emission features (1,2) not due to the ice or background environment. (C) presents a fine-scale spectral map with a spatial resolution of 100 um, overlaid on a visible context image.

Acknowledgements

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References

[1] Beegle, L. W. et al. (2015) *IEEE, 90,* 1-11.
[2] Knowlton, C. et al. (2013) *Biology*, *2,* 206-232.
[3] Asher, S. A. and Johnson, C. R. (1984) *Science, 255,* 311-313.
[4] Bhartia, R. et. al. (2010) *AEM, 76,* 7231-7237.
[5] Zacny, K. et al. (2016) ASCE Earth and Space.

Additional information

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