BIOLOGICAL SITE LOCALIZATION ON MARS USING BIO-EFFLUENT PLUME TRACING. D. Banfield[1], B. Lamb[2], D.C. Hovde[3], T. Ferrara[4], [1]Cornell University (banfield@.astro.cornell.edu), [2]Washington State University, [3]Southwest Sciences, Inc., [4]GHD, Inc.

Introduction: Any effort to directly sample extant life (or other interesting venting features, e.g., fumaroles) will require a technique to "hunt" for the precise location on Mars. Except for very clear geomorphic features visible in high-resolution imagery, biological sites identified by the spectral signatures of bio-effluent emissions from orbit will likely be constrained only to within a few km, leaving a disconnect between the precise site and that achievable from orbit. We have developed techniques that would be effective in identifying and navigating to the source of a bio-effluent plume from a mobile platform on Mars like a Rover.

We assume that the active biological site would be emitting some characteristic bio-effluent that could be used to localize the source by tracing its plume to its source. In our field experiments, we use CH_4, but any other specific tracer gas would be feasible for use. In our terrestrial experiments, CH_4 is not negligible in the background, and yet successful searches were still feasible, so negligible background is not strictly required, but is helpful. Our techniques are adapted from terrestrial methods to identify gas leaks in pipelines and gas transmission facilities, as well as bio-mimetically adopting strategies from animals that hunt their prey using bio-effluent plume tracing, particularly relatively slow moving animals like crabs relevant to slow-moving Mars rovers.

Plume Tracing: To mimic the techniques anticipated to be useful under the scenario of deployment on a (single, slow-moving) Mars rover, we aimed for a technique that could localize a plume source through successive approximation from data taken from a single mobile platform. The fundamental observables are the bio-effluent concentration and the wind advecting the tracer. Ideally, one would use a DIAL LIDAR to detect the spatial distribution of the tracer, and a Doppler LIDAR to measure the wind over the same volume. However, both of these are substantial, complicated instruments that are unlikely to be deployable on a Mars rover. Instead, one can accommodate a Tunable Laser Spectrometer (TLS), tuned to a particular molecular species, akin to the TLS incorporated in the MSL/SAM instrument (that can detect CH_4), or the water vapor sensor that flew on Mars Polar Lander. Additionally, one can accommodate a Martian sonic anemometer, as has been proposed for several recent Mars missions[1].

Fast-response instrumentation is critical in this effort, to detect the plume and the turbulent winds advecting it on timescales set by the turbulent eddies in the flow. This demands the open-sensing, fast-response capabilities of the tunable laser spectrometer and the sonic anemometer.

Field Trials: We tested a succession of plume tracing techniques appropriate for use on Mars, using a sonic anemometer and a TLS in Mars analog studies with known sources of CH_4. The first techniques used only the wind azimuth of the peak tracer concentration to identify the direction to the source. Successive locations allowed triangulation to the source. This technique was very successful and provides a credible approach for use on Mars. The second technique used the statistics of the turbulence and the tracer concentration to estimate the range to the source as well as its azimuth. This technique was helpful, but not without challenges. The third technique used an ensemble of forward modeled putative plume sources, given the observed winds (assumed homogeneous over the whole region) to identify the source region. This technique proved very capable of identifying the real plume source region.

Summary: We have developed and matured plume tracing techniques applicable for use on a Mars rover to find biologically interesting sites. The instrumentation proposed is currently at TRL5+ and credible for inclusion on a Mars rover. We also plan to adapt these techniques back to terrestrial gas leak localization where their roots are found.

References:

[1] Banfield, D., D.W. Schindel, S. Tarr, R. Dissly (2016) J. Acoust. Soc. Am., 140, 1420.