# Magic Staff: An tool for frozen volatile hunting

Artemis SDT White Paper

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"Magic Staff" is a concept for a simple tool that the Artemis astronauts can use to rapidly locate accessible frozen volatiles. Given that Artemis missions will be targeted to landing sites close to the lunar poles, we expect that searching for volatile materials will be one of their prime activities. Since the astronauts will be equipped to collect and encapsulate samples to return to Earth for detailed analysis, it should not be necessary to provide them with means of detailed in-situ volatile characterization. Instead, it would be most desirable to equip them with a simple and fast tool to help them to definitively locate accessible volatiles for collection.

Of the various methods of volatile detection that are potentially available, none comes close to evolved gas analysis in terms of its simplicity, speed, interpretability and overall reliability. Basically, any substance that tends to become a gas at room temperature can be classified as a volatile, so if gases are evolved from a heated sample, the sample therefore must contain volatiles.

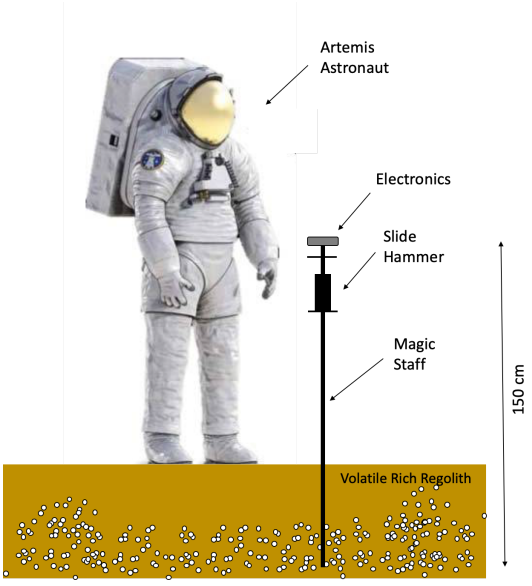


Fig. 1. Magic Staff scale drawing.

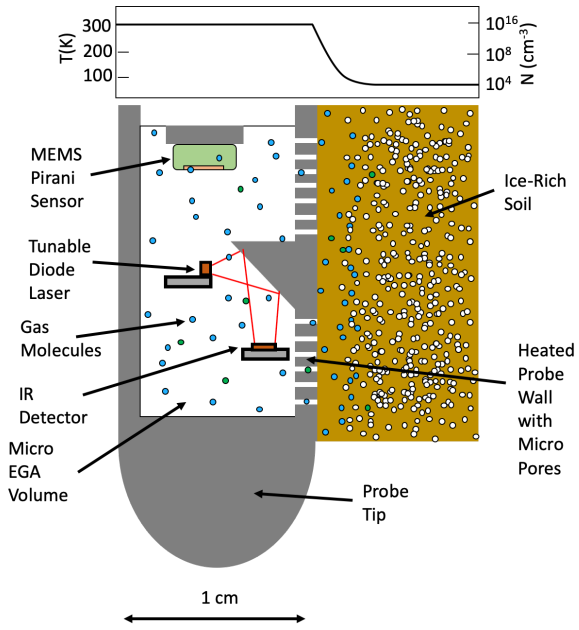


Fig. 2. Magic Staff micro evolved gas analysis package detail.

As a byproduct of a proposal that we are developing for NASA's university-led LuSTR program, we have identified a simplified approach for conducting evolved gas analysis that may be adaptable for use by astronauts. We are calling this new tool the Magic Staff. As shown in Fig. 1, the staff consists of a thin, stiff < 1cm diameter, 150 cm long rod that can be manually inserted into the regolith. As illustrated in Fig. 2, the temperature at the tip of the rod is heated to maintain it at room temperature (~300K) and once emplaced, any frozen volatile material in close contact with the rod will be rapidly sublimated. The sublimated volatiles flow in and out of a small chamber near the tip of the rod that contains a micro evolved gas analyzer package. The package consists of a MEMS Pirani sensor that measures total pressure, and a miniature tunable diode laser spectrometer that measures water vapor. Both sensors have commercial and space-flight heritage, and have sufficient sensitivity to detect ppm or potentially ppb concentrations of volatiles in the regolith.

Our scenario for the use of the Magic Staff on a volatile-hunting EVA is as follows: The astronaut would turn on the staff to activate its tip heaters and note two evolved gas sensor signals, which should read zero while the staff is out of the ground in vacuum. She would then walk to a potentially promising location and push the staff into the ground to a depth of up to 50 cm below the surface. The staff would be equipped with an impact hammer along its shaft to enable her to pound the staff into and out of the ground if required. Once emplaced, the staff would take only a few seconds to heat the first layer of surrounding regolith material, and if volatiles are evolved, the evolved gas sensors would register positive signals. The Pirani sensor would provide an indication of total volatile content, whereas the tunable diode laser sensor would provide a 100% specific indication for the presence of water. The entire measurement process should take less than a minute. The staff should require no cleaning, no consumables except for battery power, and should be capable of being reused hundreds of times. The Magic Staff can enable astronauts to efficiently (and potentially enjoyably?) hunt for volatiles over a wide and diverse area.