New Insights in Geobiological Characterization of Terrestrial and Planetary Underwater Vent Systems

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Hydrothermal vents are some of the most exciting candidates for habitable environments on Ocean Worlds. To characterize the habitability of a hydrothermally active region, it is necessary to not only compare different vent sites in the same area, but to monitor them over time with high frequency techniques that can capture the episodic nature of geochemical and metabolic changes.

In response, we are developing InVADER (In-situ Vent Analysis Divebot for Exobiology Research), an integrated imaging and multi-spectroscopy instrument capable of in-situ, rapid, long-term underwater analyses. Such analyses will be critical for finding and studying life and life's precursors at vent systems on Ocean Worlds.

InVADER allows, for the first time, in-situ, autonomous, non-destructive measurements of a) disequilibria, composition, mineralogy of hydrothermal chimneys and precipitates, b) relevant small-scale features that indicate vent geochemistry and/or habitability, and c) the presence and distribution of organics and biomass. To capture the dynamic nature of hydrothermal vent systems which can undergo significant changes over short periods of time; a system capable of high-frequency, continuous monitoring over longer time periods is required.

InVADER fills these gaps, and advances readiness in vent exploration on Earth and ocean worlds by simplifying operational strategies for identifying and characterizing submarine vents. InVADER optimizes auto-adaptive data collection strategies to capture evolving geochemical processes during autonomous exploration of vent systems in Ocean Worlds.