LIGHT IN THE THERMAL ENVIRONMENTS OF AN OCEAN WORLD: GROVELING FOR PHOTONS, OR LIVING IT RICH? J. D. Rummel, SETI Institute, P.O. Box 2838, Champlain, NY 12919, USA <jrummel@seti.org>.

Introduction: When deep sea hydrothermal vents on Earth were first discovered in the Pacific in February 1977, the research cruise was notable in that there were no biologists onboard either the submersible *Alvin* or her support vessels. Nonetheless, the chemosynthetically based ecosystem at those warm-water vents was amazing [1]—as were the organisms surrounding hotter, "black smoker" vents discovered on later cruises [2]. Whereas chemosynthesis was known to occur in limited amounts in anaerobic environments, the existence of a chemosynthetically based ecosystem that supported large animals (e.g., fish, shellfish, tubeworms) had not previously been suspected, and never before had been seen or sampled.

Later investigations of the Mid-Atlantic Ridge also revealed deep (~3,600 m vs. ~2,500 m in the Pacific) hydrothermal vents that had a distinctly different fauna from the Pacific vents. In particular, they were swarming with an odd, apparently "eyeless" shrimp species [3], thus named *Rimicaris exoculata*. After significant study, Van Dover [4] and her colleagues demonstrated that those shrimp were not eyeless, but instead had planar eyes on their backs that were sensitive to both visible and infrared light.

But since the vents were supposed to be in darkness all the time, why?

Later research [5] involving the use of an astronomical CCD imager demonstrated that the vents were glowing in the infrared, and more focused measurements demonstrated that there was light in the visible range, as well [6]. As such, natural questions that were asked [7] included whether the geophysically generated light at hot vents could have photosynthetic or other metabolic consequences, and also whether the "light" at the vents might be part of a much larger story, including both the history (and preservation) of photosynthesis on Earth [8], especially because the history of hydrothermal activity is anticipated to have predated the origin of life on Earth, and has been a continuous phenomenon on a geological time scale. It has also been considered that this light might have served as the locus of the evolution of biological photochemical reactions or adaptations on worlds other than the Earth, especially with respect to the ocean worlds of the solar system [9].

Finding a Unicorn? Interest in the light at deep sea "black smoker" vents and under vent structures known as flange pools—where the buoyant, hot water distributes part of its mineral load before escaping around the rims of the inverted "pool" led to a search for indigenous phototrophic organisms enjoying the good life on the sea floor (Fig. 1). Whereas the rim of a

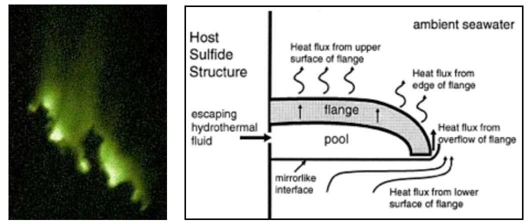

Fig. 1. A glowing vent (IR); the structure of a flange pool [5, 10].

hot (350 C) vent provided only the smallest possible habitat for a phototroph looking to catch photons without being poached, the environment under a flange pool is decidedly better, allowing the integration of light from the entire 'surface' of the pool to illuminate the slope below the pool itself. Eventually, Van Dover and her colleagues discovered anaerobic green sulfur bacteria at the vents—organisms that depend on the geophysical light at the vents for the oxidation of sulfur compounds, and thereby to reduce CO_2 [11].

Looking for Obligate Phototrophs, or Their Remnants, on an Ocean World: Not currently discussed in the Europa Lander SDT Report [12], the application of knowledge about seafloor phototrophy should begin with an understanding of the relationship of such organisms to anoxygenic phototrophs in aquatic environments on Earth, once unknown, and now thought to represent as much as 11% of all oceanic carbon fixation [13]. If these organisms are thriving beneath a europan ocean, the remains of their biophysical structures and their chemistry should be detectable, even within the contemporary surface ice pack.

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