SEAFLOOR FLUID FLOW AND THE SEARCH FOR EXTANT LIFE: ESCAPING EARTHLY PREJUDICES.

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Introduction: On Earth, diverse forms of seafloor fluid flow lead to chemical disequilibria between the fluids circulating beneath the seafloor and the overlying ocean. Mixing of these fluids at the point of outflow at the seabed can give rise to chemical reactions with an associated release of energy that can be exploited by microorganisms to sustain chemosynthetic ecosystems. Because at least some of these life sustaining systems have the potential to operate independent of sunlight, the question arises: could similar habitable environments recur on other ocean worlds and, if so, might they be inhabited? While Earth's seafloor may provide an excellent launch-pad for such hypothesis generation, however, it is important not to cling too closely to what we already know from Earth's oceans – not least because, as we continue to explore, we continue to find evidence for new styles of submarine fluid circulation that we had not previously accounted for.

Seafloor fluid flow in an ice-covered ocean: During a recent expedition to the Arctic Ocean in 2016 we dived our new prototype under-ice vehicle, NUI, to the seabed at the Karasik Seamount [1] but also conducted extensive more conventional water column and seafloor examinations at much greater depths, >3000m, in an immediately adjacent section of the ultra-slow spreading Gakkel Ridge [2]. While this was a location at which first evidence for high temperature "black smoker" hydrothermal venting had been reported previously [3, 4], our more recent investigations require us to re-evaluate those conclusions. Specifically, our data do not allow us to sustain the earlier conclusion that the source of the water column chemical anomalies that we detected were from a conventional "black smoker". Rather, we require the source for our data – on the assumption that there is a single source that accounts for all the data that we have acquired – that is simultaneously: (a) high temperature, (b) chemically reducing relative to the overlying deep ocean, (c) rich in hydrogen and methane, (d) deficient in dissolved hydrogen but (e) rich in iron – the latter, on the assumption that the abundant particle concentrations detected in this dispersing plume are not, instead, due to a proliferation of microbial activity. Whichever explanation proves the more consistent (analysis of the particulate samples is underway) what these data point to is a seafloor fluid flow system quite unlike any that we have seen before and, hence, quite different from what we were looking for at the start of our expedition.

Expecting the Unexpected: A key take home message, thus, is to use ocean exploration on Earth to inform rather than dictate our future off-world exploration strategies. Field observations of Europa and Enceladus do not allow us to determine whether internal planetary convection, comparable to Earth's current or past plate tectonics, might exist for such systems (now or in the past), but direct observations of Io and Mars do allow us to conclude that isolated point-source volcanism is (or has been) plausible. This can be used as a driver – for example through the "SUBSEA" PSTAR program – to investigate novel seabed geologic settings and to investigate how different conditions of P, T, even with the same basic seawater-basalt water:rock system can give rise to varying fluid compositions and associated energetics. In future, for Galilean satellites, we may need to pursue fieldwork at even greater pressures to replicate those seafloors, comparable to Earth's deepest trenches. Just as we continue to make new and unexpected discoveries at Mid-Ocean Ridges – the places that Earth based ocean scientists have studied most – so we can expect to expand our vocabulary of what is possible, both in terms of water-rock reactions and the microbial metabolisms that could be supported, as we continue to explore further: within Earth's oceans and beyond.

References:

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