Tools of the trade

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Exploring the hadal zone with lab-on-chip sensors

Hadal trenches are located at depths of 6 km to 11 km and represent the deepest parts of the global ocean. These habitats are recognized as important depositories for organic matter and could be of global importance in oceanic carbon sequestration. Trench systems are enriched with relatively labile organic material that is intensely mineralized by largely unexplored microbial communities thriving at extreme hydrostatic pressure. However, the extreme depth poses considerable challenges for sampling and exploration, leaving the hadal realm still relatively unexplored.

Lab-on-chip sensors are submersible miniaturized versions of traditional laboratory benchtop systems. Attached to an external battery supply and preferred deployment platform, such as a mooring, autonomous float, from a ship or even standalone, the sensors make automated measurements of carbon dioxide and dissolved nutrients, including nitrate, nitrite, phosphate, and iron. Lab-on-chip sensors utilize microfluidic technology to enable high-resolution and high-frequency measurements to be made at the seafloor. This technology eliminates the need for manual sample collection and subsequent laboratory-based analysis, which is often expensive, labour intensive and time-consuming, leading to intermittent datasets. The microfluidic design also means that the system only requires low volumes of samples, blanks and reagents, which allows for frequent calibrations and drift compensation during deployments, increasing the accuracy of the in situ measurements.

Lab-on-chip sensors have the potential to advance knowledge of the hadal zone. Testing and optimization of lab-on-chip sensors for use at hydrostatic pressures equivalent to 10-km water depth are already underway, using high-pressure chambers in the laboratory to simulate conditions in the hadal zone. Deploying lab-on-chip sensors integrated into lander systems in deep ocean trenches will provide important insights into element cycling and microbial processes that are currently unattainable. Such information, including on ocean mineralization of organic material in these trenches, will improve estimates of global ocean carbon sequestration.

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Competing interests
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