Deep-Sea Hydrothermal-Vent Sampler

This apparatus collects hydrothermal-plume samples uncontaminated by surrounding water.

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An apparatus is being developed for sampling water for signs of microbial life in an ocean hydrothermal vent at a depth of as much as 6.5 km. Heretofore, evidence of microbial life in deep-sea hydrothermal vents has been elusive and difficult to validate. Because of the extreme conditions in these environments (high pressures and temperatures often in excess of 300°C), deep-sea hydrothermal-vent samplers must be robust. Because of the presumed low density of biomass of these environments, samplers must be capable of collecting water samples of significant volume. It is also essential to prevent contamination of samples by microbes entrained from surrounding waters. Prior to the development of the present apparatus, no sampling device was capable of satisfying these requirements.

The apparatus (see figure) includes an intake equipped with a temperature probe, plus several other temperature probes located away from the intake. The readings from the temperature probes are utilized in conjunction with readings from flowmeters to determine the position of the intake relative to the hydrothermal plume and, thereby, to position the intake to sample directly from the plume. Because it is necessary to collect large samples of water in order to obtain sufficient microbial biomass but it is not practical to retain all the water from the samples, four filter arrays are used to concentrate the microbial biomass (which is assumed to consist of particles larger than 0.2 μm) into smaller volumes. The apparatus can collect multiple samples per dive and is designed to process a total volume of 10 L of vent fluid, of which most passes through the filters, leaving a total possibly-microbe-containing sample volume of 200 mL remaining in filters.

A rigid titanium nose at the intake is used for cooling the sample water before it enters a flexible inlet hose connected to a pump. As the water passes through the titanium nose, it must be cooled to a temperature that is above a mineral-precipitation temperature of 100°C but below the upper working temperature (230°C) of switching valves and tubes in the apparatus. The sample water then passes into a manifold tube, from whence the switching valves can direct the water through either a bypass tube or any one of the filter arrays, without contamination from a previous sample. Each filter array consists of series of filters having pore sizes decreasing in the direction of flow: 90-, 60-, 15-, and 7-μm prefilters and a large-surface-area 0.2-μm collection filter. All the filter taps are located between the intake and the bypass tube so that each time the bypass tube is used, the entire manifold tube is flushed as well.

The switching valves include five passive ones (a check valve for the bypass tube for each of four filter arrays) at the upstream (manifold) end and an active one (a five-position actuated valve) at the downstream end. The incorporation of the check valves at the upstream end makes it unnecessary to use actuated valves at both ends. Once the actuated valve has been turned to the bypass position, the pump begins to flush the intake and manifold of any particulate matter that may have accumulated. After flushing, sampling is started by setting the actuated valve to pass water through one of the filter arrays. The process of flushing and sampling is repeated for each of the four filter arrays.

Because the apparatus is rated to a depth of 6.5 km, it is pressure-compensated; as the pressure increases between atmospheric at the ocean surface and about 10 kpsi (≈69 MPa) at maximum depth, the volume of water within the system decreases by about 2.7 percent. A flexible membrane within the apparatus accommodates the compression and expansion of water upon descent and ascent, respectively.

The apparatus includes a system for monitoring and regulating temperatures, pressures, and flow rates throughout the system. This control and monitoring system includes a small microprocessor, motor controllers (for the pump and the valve actuator), the aforementioned temperature probes, pressure sensors, and a serial data link to a laptop computer aboard a submarine or other vessel used to bring the apparatus to and from the hydrothermal vent.

This work was done by Alberto E. Behar, Kasthur Venkateswaran, and Jaret B. Matthews of Caltech and Cesar Rivadeneyra, James C. Bruckner, Edmond So, and Goran Basic of the International Space University for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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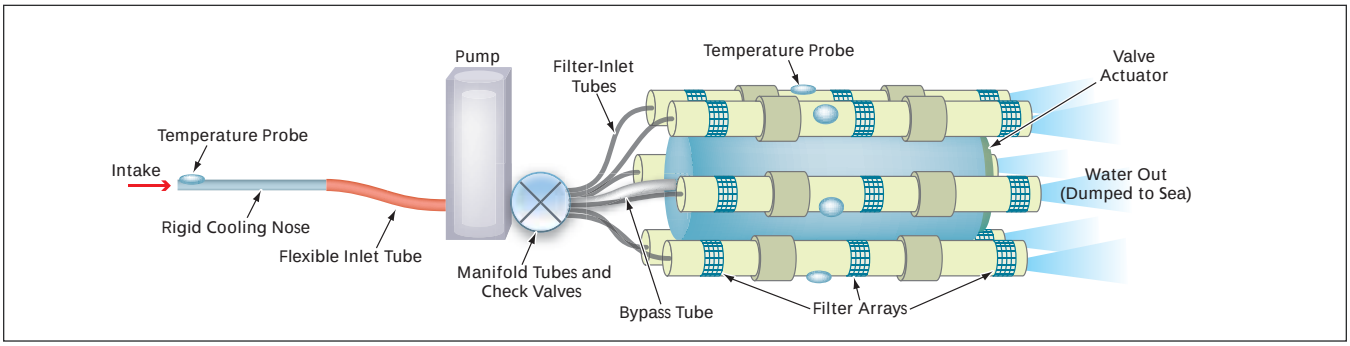

The **Intake Is Positioned** in the plume of a hydrothermal vent with the help of temperature-probe readings, then water is pumped from the intake through filter arrays to collect microbes.