Development of the DOMS Deep-Ocean Mass Spectrometer System

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Flow from submarine seeps is usually slow, and changes in dissolved constituents reflect these low rates, but the concentration trends over time are potential precursors of tectonic events such as earthquakes or gravity-driven slumps, or other changes in the local or regional stress field that could be better understood via time-series studies. With funding support from the National Science Foundation, our engineering design team constructed a new mass spectrometer-based system for in situ analysis in the deep-ocean environment over prolonged deployments. Our design goals were a depth capability of up to 4000 m water depth (400 bars) and autonomous operation for six months to a year, depending upon battery system or other deployment circumstances. We chose a membrane introduction mass spectrometry (MIMS) sampling approach, which allows dissolved gases and volatile organics introduction into the mass spectrometer. The membrane was successfully tested to 400 bars in a series of long-term hydrostatic tests. Power management via the embedded computer system, with its custom electronics and software, provides a long-term deployment capability of the peak 100 W system. The entire system fits within a 6.5-inch outside diameter Ti pressure housing approximately five feet long. It consists of a 1 to 200 amu range quadrupole mass spectrometer equipped with Faraday and electron multiplier detectors, compact turbo-molecular and backing vacuum pumps, internal waste vacuum chamber, and 0-50°C digital temperature probe. We also designed a deployment mainframe for the instrument, the 4500 Watt-hr external battery, and the Scripps Institution of Oceanography CAT (Continuous Aqueous Transport) flux meters, for storage of both dissolved molecular species and dissolved gases, so that on-site chemical comparisons of vent fluids could be accomplished. With R/V Atlantis-Alvin, we made our first field deployment in June, 2005 at 1000 m depth on the Costa Rica margin for a planned 4-month monitoring experiment of methane-rich cold seep mounds located about 60 km offshore.