Aqueous Flux Measurements at the Bush Hill Hydrate Mound, Gulf of Mexico

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As part of a collaborative and multidisciplinary project between Scripps Institution of Oceanography, Georgia Tech, and Rice, we deployed seven Scripps CAT meters [1] in the Bush Hill hydrate mound area of the Gulf of Mexico. Our purpose was to provide; 1) quantitative measurements to enhance the physical and chemical framework for associated biological findings from the NSF- Life in Extreme Environments (LExEN) program, 2) produce standalone quantitative constraints to refine the relationship of fluxes and flux pathways to dynamics of gas hydrate reservoirs, and 3) yield site survey data for proposed ODP gas hydrates-related drilling (Kennicutt, GERG-TAMU, lead proponent).

The Chemical and Aqueous Transport (CAT) meter uses the dilution of a chemical tracer to determine flux rates. An osmotic pump injects a tracer at a constant rate into the water stream as it moves through the outlet tubing. A portion of the fluids moving out of the top of the chamber is collected in sample coils, giving a unique pattern of chemical tracer distribution. The two sample coils allow both positive and negative flow to be measured and give a serial record of the flow rates. The Rb and Sc tracers are analyzed by optical emission spectrometry and allows a flux rate range of 0.01 to 1500 cm/yr. At high outflow, seawater is flushed from the meter's dead volume allowing a serial record of the outflow fluid chemistry to also be obtained. The temporal resolution of the measurements can be as high as 0.5% of the deployment time.

During the LExEN cruise aboard the R/V Seward Johnson II in July 2002 we deployed the seven CAT meters in the area of the hydrate mound using the Johnson Sealink submersible. Due to the small number of sites that we are able to instrument, our strategy has been to attempt to extrapolate from these measurements by characterizing the flow regime of different biological communities and surface geology/morphology. The meters were deployed on different types of microbial mats and bivalves as well as sites without macrofauna. Meters were placed adjacent to the surface hydrate mound, in the carbonate rich areas to the north, and sedimented areas to the south.

During the October, 2002, R/V Seward Johnson cruise the instruments were all successfully recovered via their acoustic release mechanism. Flow rates were observed to range from less than 1 mm/yr to as high as 1 m/yr with significant temporal variability. A significant hydrological event was observed to occur on four of the instruments midway through the deployment period. There is evidence that this event was related to a gas expulsion event. Two of the instruments, both located on microbial mats, indicated a period of no flow immediately before the event and downflow after the event which diminished and switched to rapid upflow of gas saturated fluids. This sequence is consistent with the formation of a gas bubble in the near surface, and subsequent expulsion of this gas. Two nearby instruments recorded a rapid increase in flow rates at the time of the event with a subsequent decrease in rates to similar or lower values than before the event. These results are very similar to those from our previous studies at Hydrate Ridge [2-4]. Both of these sites have gas hydrates at and near the sediment surface and are located near the upper limit of the hydrate stability zone. This results in a hydrologically dynamic environment with episodic free gas expulsion and a high degree of hydrologic variability, primarily driven by the free gas dynamics.

These results serve to warn us that simple models of gas, fluid, and energy transport are not applicable to many gas hydrate environments. High degrees of spatial and temporal variability may be the norm in the shallow gas hydrate environment. Only through long-term measurements over a significant spatial extent will we be able to adequately constrain these models.

References

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