Summary Report
Hydrate Drill: development, testing, monitoring
April 2001 through May 2003

Submitted by

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Overview:

This is a summary report documenting effort and accomplishment on two related awards from NETL to Texas A&M University – I.R. MacDonald, principal investigator. The awards were tasked with advancing the technical capabilities for sampling and monitoring shallow deposits of gas hydrates. Major thrust areas have been development, fabrication, and testing of a unique hydrate drill system for recovering intact samples of gas hydrate and time-series monitoring of the sampling sites to quantify in-situ physical and chemical properties of gas hydrate and interaction of the deposits with biological and oceanographic processes.

Year 1

The project is tasked to design, fabricate, and test a portable hydraulic drill. The drill is to be deployed from a submersible (e.g. Johnson Sea Link). The drill will collect multiple short cores of gas hydrate from shallowly buried deposits of gas hydrate at continental slope depths (e.g. 1860 ft in the northern Gulf of Mexico).

Accomplishments during year 1 include completion of design and fabrication in collaboration with Harbor Branch Oceanographic Institution. (Figure 1). The drill has six titanium coring bits that are detachable and measure 11.5 inches long by .875 inches id. For operation, the drill is to be placed in position by the mechanical arm of the submarine while separate hydraulic functions rotate and advance the cores. Constant pressure on drill-face is maintained by spring tensioner. After one core has been collected, the bit is detached into a collection chamber and a new bit is rotated into position. Recovery of samples is accomplished use of a pre-existing pressure chamber.

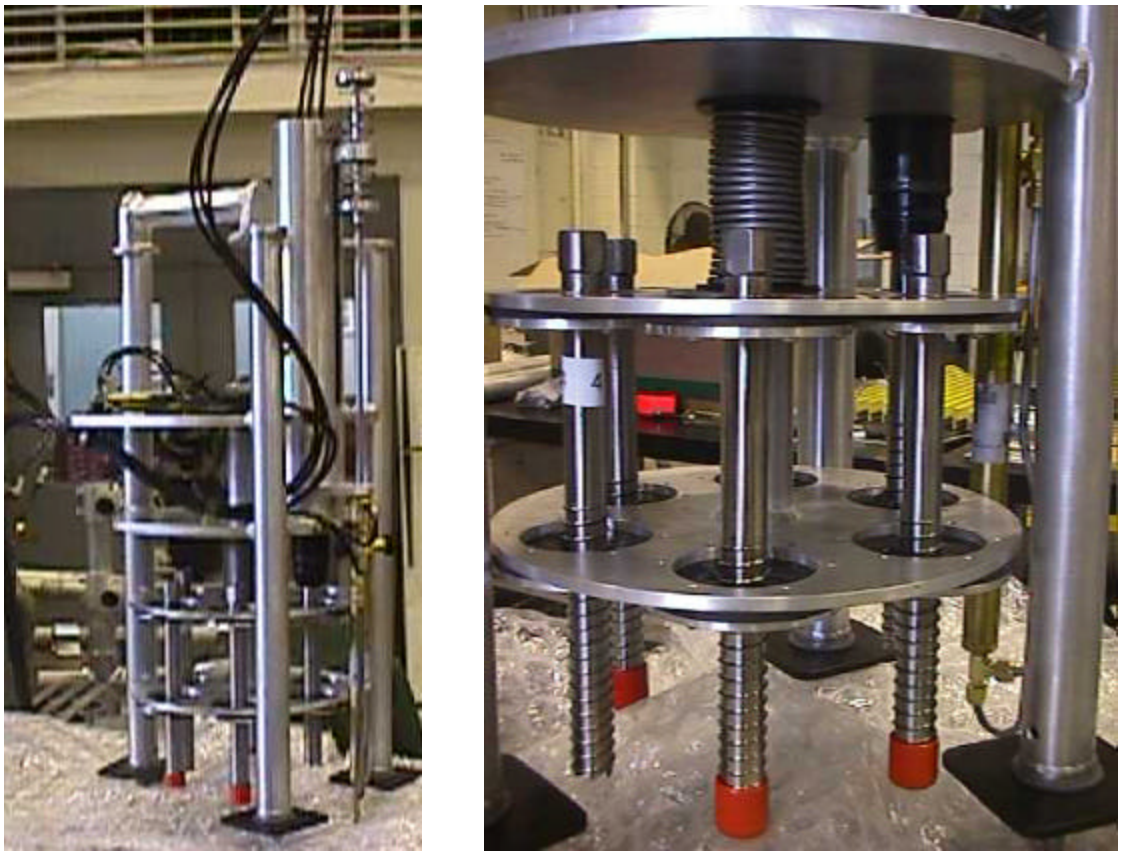

Figure 1. Hydrate drill during initial fabrication (left) showing detail of six, detachable coring bits (right).

Field program

A program of sample collection, observation, and instrument deployment was completed during a cruises with the RV SEWARD JOHNSON II and the submersible JOHNSON SEA LINK in the Gulf of Mexico during July 3-18, 2001. During this program, the hydrate drill was tested at hydrate deposits located in the Bush Hill/GC 185 and GC 234 sites (Figure 2). Temperature measurements, time-lapse photographic monitoring, and documentation of gas hydrate in-situ characteristics were completed at these sites and at the Mud Volcano and Brine Pool sites (Figure 2).

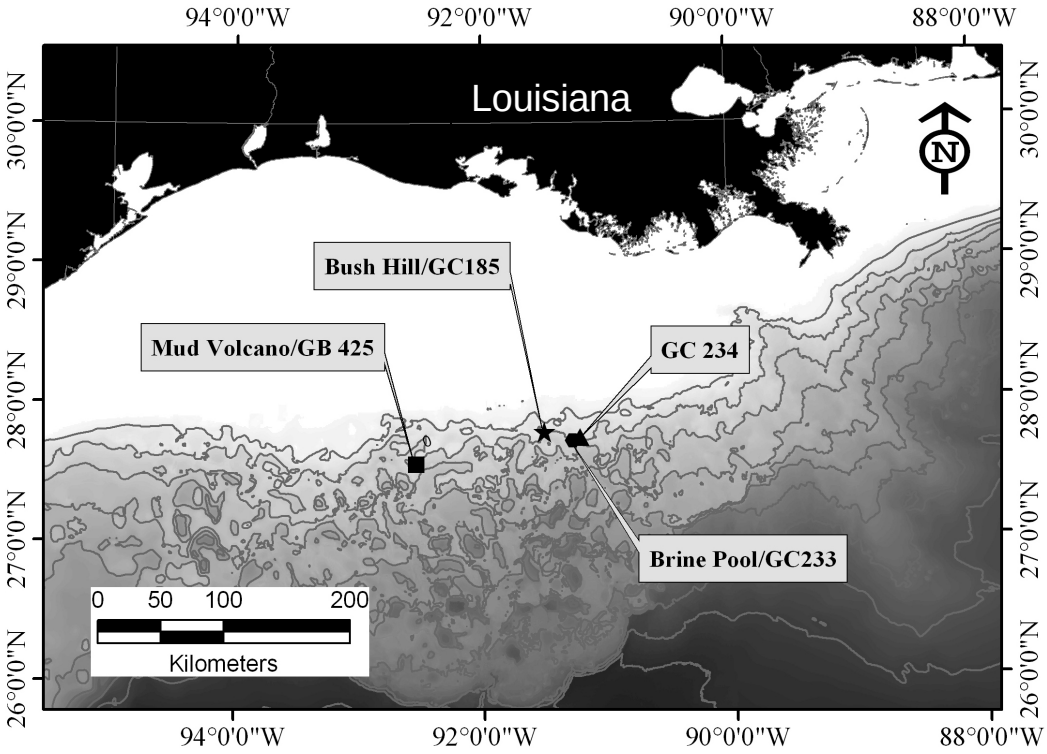

Figure 2. Regional map showing study sites in the northern Gulf of Mexico offshore Louisiana. Most sampling activity was concentrated at the GC185 and GC234 sites.

Tests of the hydrate drill were successful, but identified several issues requiring more work. The drill was deployed on a These efforts were described in detail in cruise reports submitted to NETL in September 2002. To summarize the field program, the PIs (Kastner and MacDonald) and their students and technicians carried out a series of dives with the submarine Johnson Sea Link, supplemented with sampling and observation from the surface ship. The activities included collection of gas hydrate, sediment, water, and other materials from gas hydrate and seep sites located at about 550 m depths on the continental slope south of Louisiana (Fig 2). The sites are designated GC185 and GC234—based on the MMS lease blocks in which they are located. Collection methodology utilized unique sampling equipment that has been designed and fabricated by the PIs during this and related projects. The cruise participants also deployed

advanced instruments to monitor and sample the physical and geochemical environment at the study sites. These instruments included a digital time-lapse camera and autonomous recording thermistors to measure the temperatures of water and the interior of hydrate deposits (Fig. 3). Finally, MacDonald arranged to collect a series of six RADARSAT synthetic aperture radar (SAR) images over the study region. The overall result of this effort was to establish a seafloor observatory studying gas hydrates.

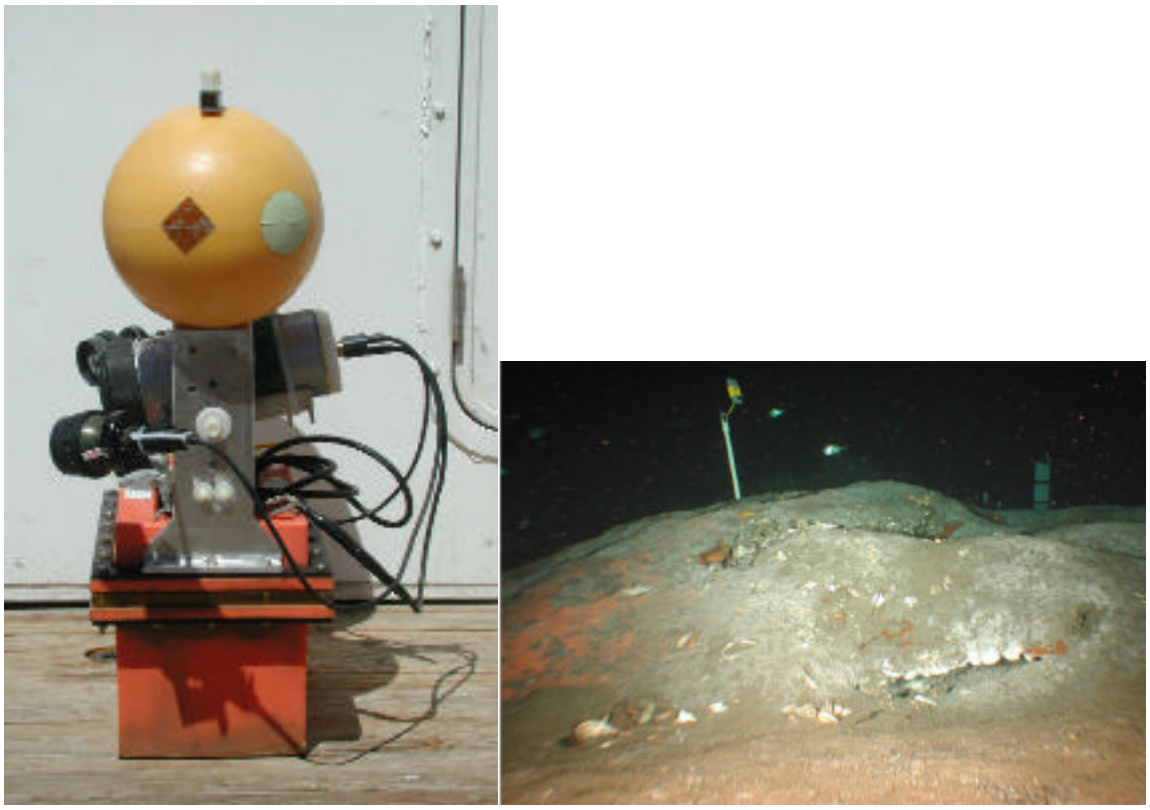

Figure 3. Time-lapse camera (left) which was deployed to monitor gas hydrate mound at Bush Hill. Thermistor probes were inserted into holes drilled in the mound (right).

Follow-up

After completing the cruise in 2001, design issues with the drill were address in collaboration with Harbor Branch Oceanographic Institution and the University of Nebraska ice coring group. The drill was modified to accommodate a larger core bit and a state-of-the art core bit was designed (Fig. 4). Two large bits were fabricated. These bits accommodated cores up to 10 inches long and 2.5 inches in diameter. Repairs were made to other equipment and data were analyzed and reported. Presentation with published abstracts that acknowledged DOE-NETL support were as follows:

MacDonald, I.R. Power, D. Leifer, I. Lane, K. Youden, J. The remote sensing signature of hydrocarbon seeps and implications for carbon flux American Geophysical Union Ocean Sciences Meeting, Hawaii, Feb 2002.

MacDonald, I.R. Sobecky, P. Montoya, J. Joye, S. (2001) Deposits of gas hydrate on the Gulf of Mexico slope: A natural laboratory for hydrate research. Second International Symposium for Deep-Sea Hydrothermal vent Biology, Brest, France, page 88

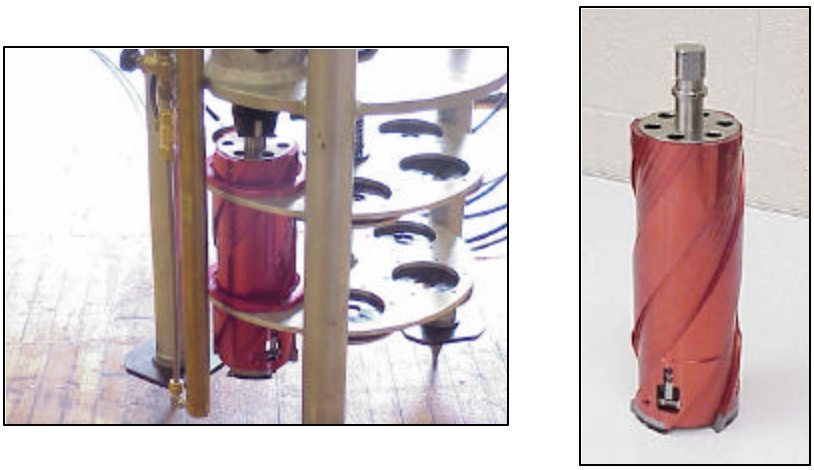

Figure 4. Modification to hydrate drill to accommodate large bore hydrate core.

Year 2

The major effort during the second year of this project was to utilize the large bore hydrate drill in support of the Kastner-MacDonald research program (GHOST), sponsored by DOE-NETL and the LexEn program sponsored by NSF. Additional effort included recovery and redeployment of monitoring instruments and collection of additional satellite imagery.

Field work

The hydrate drill was deployed on two submersible cruises. The first cruise (GHOST) was completed during 6-14 June. The second cruise (LExEn) was completed during 3-20 July 2002. The modified drill system was successfully deployed and was used to recover large and small diameter pieces of hydrate (Fig. 5). However, problems with the motor drive system surfaced during the cruise which required modification and repairs that could not be accomplished at sea.

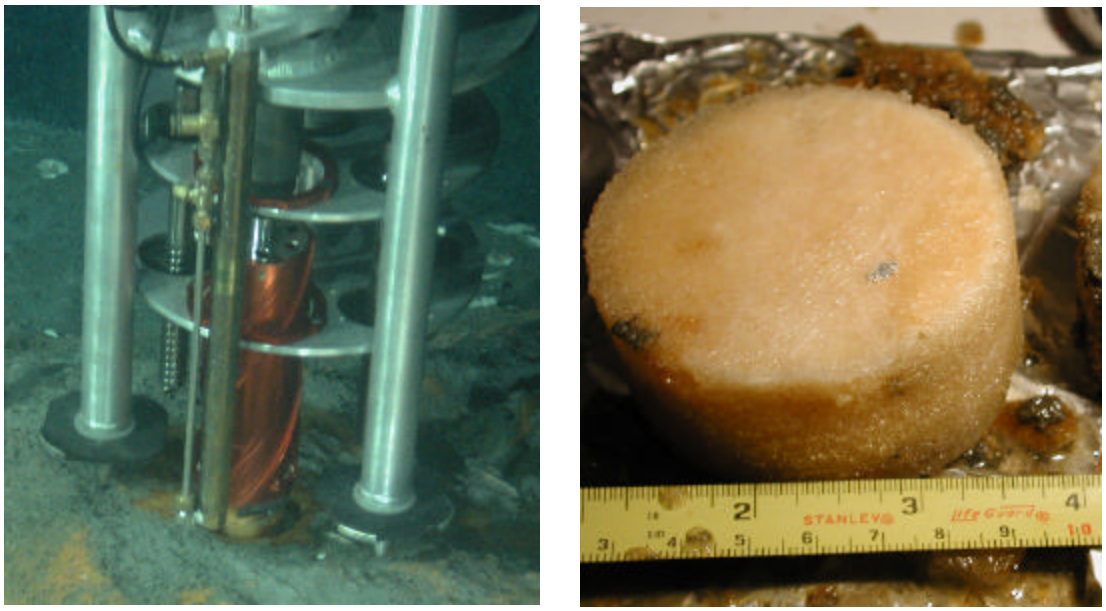

Figure 5. Hydrate drill collecting large core on sea floor (left) and section of core in laboratory (right).

The time-lapse camera system and recording thermistors were recovered during the GHOST cruise. The camera had recorded 96 days of data recording 4 pictures per day. The thermistors recorded water and hydrate temperatures during 327 days (the entire inter-annual interval—see Fig. 6). The camera was redeployed and set to record one picture per two hours with the intention of recovering it during the LExEn cruise in July.

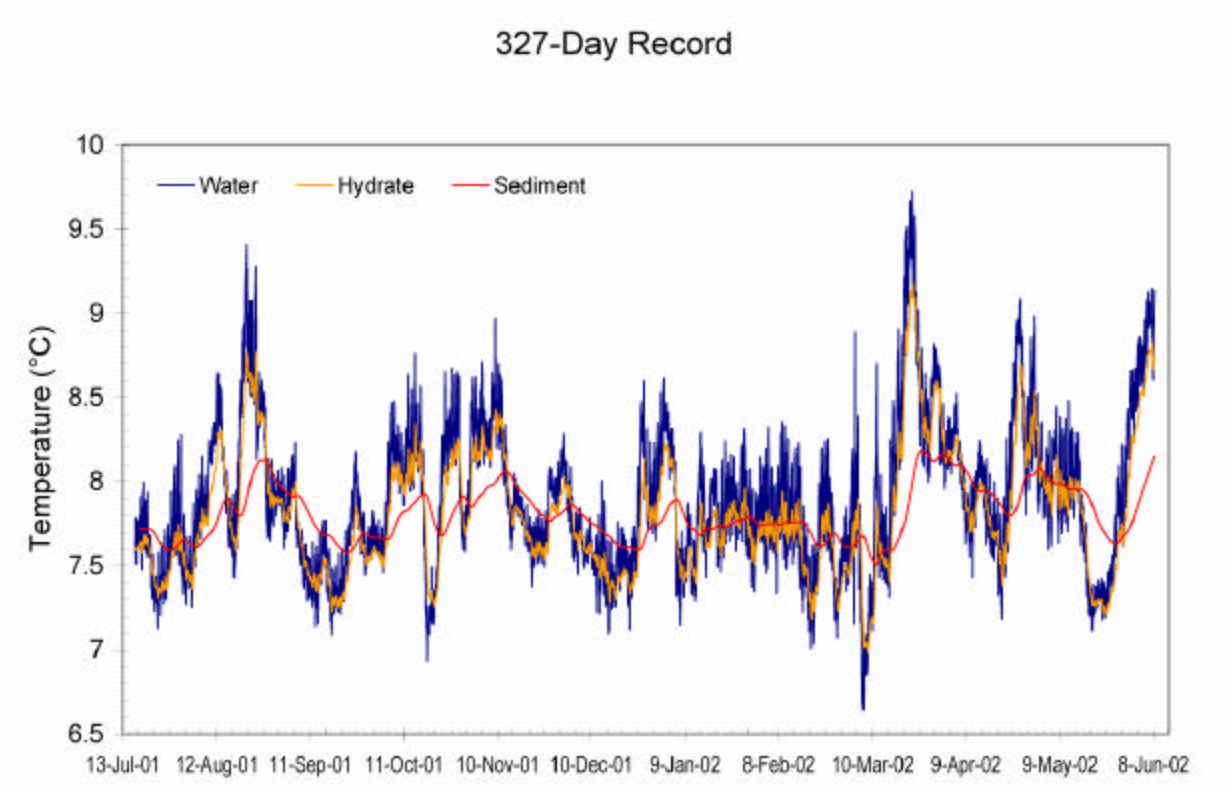

Figure 6. Temperature record from three recording thermistors deployed at Bush Hill. *Water* is bottom water. *Hydrate* is temperature of hydrate recorded by probe inserted in 5-inch deep hole drilled in hydrate mass (see Figure 3 for picture of thermistor probe in hydrate deposit). *Sediment* is temperature of sediment recorded by probe inserted 18 inches into sediment.

During the LExEn cruise, the camera system was recovered and redeployed to continue the time series. Additional samples were collected with the small diameter cores, but problems with the drive shaft limited its effectiveness. A total of 6 RADARSAT images were collected to monitor the remote sensing signature of the gas hydrate sites.

Follow up

After completing the field work, necessary modifications to the hydrate drill were made to repair problems encountered during the cruise. Field equipment was repaired and refurbished as needed. A site-visit to DOE-NETL was completed on 16 December 2002. Numerous photographs and illustrative materials were shared with personnel at the DOE-NETL. Data were analyzed and reported at meetings and in peer-reviewed publications. A list of published abstracts and peer-reviewed manuscripts that acknowledged DOE-NETL support is as follows:

De Beukelaer, S., I. R. MacDonald and J. Murray. Distinct Side-Scan Sonar, RADARSAT SAR, and Chirp Signatures of Gas and Oil Seeps on the Gulf of Mexico Slope. *Geo-Marine Letters*. (In Review)

Liefer, I. and MacDonald, I.R., Dynamics of the gas flux from shallow gas hydrate deposits: interaction between oily hydrate bubbles and the oceanic environment. *Earth and Planetary Science Letters* 21(3-4): 411-424 (20030

MacDonald, I.R., Vardaro, M. Bender, L. (2003) A Temperature and Photographic Time-Series from a Seafloor Gas Hydrate Deposit on the Gulf of Mexico Slope. Geophysical Research Abstracts, Vol. 5, 12714,

MacDonald, I.R., Sobecky, P. Montoya, J. Joye, S (2003) Research issues in the Hydrocarbon Seep System in the northern Gulf of Mexico. ASLO meeting, Salt Lake City 10-14 February 2003.

MacDonald, I.R. and I. Leifer (2002). Constraining rates of carbon flux from natural seeps on northern Gulf of Mexico slope. Shallow Gas Meeting/NATO Workshop on Gas Hydates, Baku Azerbaijan 7-11 Octobere 2002.

MacDonald, I.R., Leifer, I., Sassen, R., Stine, P., Mitchell, R. and Guinasso Jr., N., Transfer of hydrocarbons from natural seeps to the water column and atmosphere. *Geofluids* 5: 95-107 (2002)

Future Efforts

The hydrate drill and related instruments will be deployed in support of the GHOST project during a submersible cruise scheduled for 13-24 August 2003. It is anticipated that numerous hydrate samples will be collected. To extend the seafloor observatory for as much time as possible, a more powerful suite of instruments will be assembled and deployed. These instruments will include a time-lapse camera with a rotating base to enable panoramic surveillance of the seep/hydrate setting. To monitor the physical environment that controls hydrate formation and stability, a sensitive temperature, pressure, and salinity recorder will be deployed. The acoustics group at the University of Oregon has tentatively agreed to loan a recording hydrophone to the project. This instrument will record ambient noise at Bush Hill including, it is hoped, variable bubble noise generated by gas escaping through the hydrate. Baseline measurements of bubble noise will be made using calibrated hydrophones in support of this experiment. Because continuation of the project is not certain beyond 2003, the instrument array will be recovered during a cruise scheduled for September 15, 2003, which will afford approximately 30 days of data.

Following this effort, MacDonald and his students will prepare peer-review manuscripts for publication to detail the scientific results produced by this project.