

Fire in the Ice

Winter 2009  Methane Hydrate Newsletter



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ASSESSMENT OF TECHNICALLY RECOVERABLE GAS-HYDRATE RESOURCES ON THE NORTH SLOPE OF ALASKA

By the U.S. Geological Survey National Oil and Gas Assessment Team

In recognition of the importance of gas hydrates as a potential energy resource, the U.S. Geological Survey (USGS) and the U.S. Bureau of Land Management (BLM) entered into an Assistance Agreement in 2002 to assess the volume of gas that could be produced from gas hydrates in northern Alaska. This effort included a detailed geological and geophysical investigation that delineated gas hydrate occurrences throughout the Alaska North Slope (ANS). Information gleaned from the latest field research programs and hydrate production computer simulations were then used to estimate technically-recoverable gas-hydrate resource volumes. Our estimate is that there are about 85 trillion cubic feet (TCF) of undiscovered gas resources within gas hydrates on the ANS that can be recovered using existing technologies (Table 1).

The area assessed in northern Alaska (Figure 1) extends from National Petroleum Reserve (NPR) on the west through Alaska National Wildlife Refuge (ANWR) on the east and from the Brooks Range northward to the State-Federal offshore boundary (located three miles north of the coastline). This area consists mostly of Federal, State, and Native lands covering about 55,894 mi².

A critical finding of our geological and geophysical investigations is that gas hydrates on the North Slope occur within reservoir-quality sands as



Figure 1: Map showing the Northern Alaska Gas Hydrate Total Petroleum System (TPS) (shaded in tan), and the limit of gas hydrate stability zone in northern Alaska (red outline).

CRUISE REPORT: IMAGING GAS HYDRATE IN THE GULF OF MEXICO USING MARINE ELECTROMAGNETIC METHODS

By Karen Weitemeyer, Steven Constable, and the SIO Marine EM Laboratory, Scripps Institution of Oceanography.

On 7th October 2008 the Research Vessel *Roger Revelle* steamed into the Gulf of Mexico to carry out an experiment to map gas hydrates using state-of-the-art marine electromagnetic (EM) methods. (Figure 1) This work is funded in roughly equal parts by a consortium of industry sponsors, NETL, and University of California Shipfunds Committee. Over the following 18 days the science party deployed a fleet of 30 seafloor electric and magnetic field recorders a total of 94 times, broadcasting 103 hours of electromagnetic signals from a towed transmitter. While it will take some time to process and interpret the 70 Gigabytes of data collected on this cruise, shipboard appraisal shows that the quantity and quality of the data exceed all expectations.

By using equipment and techniques developed as part of the search for offshore oil and gas, and building on a pilot experiment carried out over Hydrate Ridge in 2004, our work aims to create 2-D and 3-D images of resistivity throughout the hydrate stability field. Well logs and laboratory experiments show that hydrate is more electrically resistive than host sediments, and more than ten years ago Nigel Edwards proposed the use of controlled-source EM methods as a way to evaluate the resource potential of gas hydrate. Since then several groups have fielded equipment to do just this, including ourselves, Nigel, Rob Evans, Tada-nori Goto, John Dunbar, and Katrin Schwalenberg (we were fortunate to have Katrin join our 2008 experiment). The approach used by all these workers is to drag or tow a transmitter close to the seafloor to inject an electric current across two electrodes separated by 10's or 100's of meters. An EM receiver, usually an inline electric field antenna dragged or towed some distance behind the transmitter, records the amplitude and phase of the transmitted signal. For low frequency transmissions, a DC-type resistivity measurement can be made, but higher frequency transmissions will propagate preferentially through more resistive seafloor rocks and provide greater sensitivity to seafloor structure. Magnetic field transmitters and receivers can also be used.

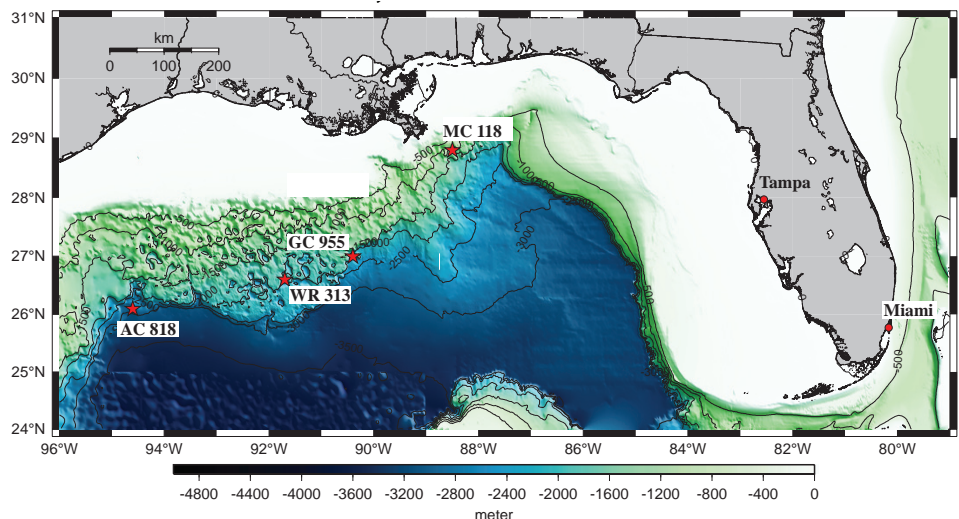


Figure 1: Map of areas surveyed in October 2008.

Several aspects of our work differentiate it from these earlier studies. The deployment of large numbers of seafloor receivers results in an expanded set of transmitter-receiver offsets and extends the depth of investigation from the seafloor to the base of the hydrate stability field, and even deeper. Seafloor recorders collected every EM component except the vertical magnetic field (E_x , E_y , E_z , B_x , and B_y). We supplemented the deployed instruments with a receiver (“Vulcan”) towed at a constant offset of 300 m behind the transmitter antenna, to provide short-offset data for all transmitter positions. Our transmitter and towed receiver operate at altitudes of 50-100 m above the seafloor, allowing us to operate in areas with seafloor infrastructure or rough terrain, rather than being dragged in contact with the sediments and rocks. The towed receiver records all three axes of electric field instead of just the inline E_y field, and because it is not in contact with the seafloor has much lower noise levels. Instead of transmitting a single fixed frequency, we transmitted a binary waveform with about two decades of frequency content, from 0.50 Hz to about 50 Hz (Figures 2, 3, 4).

The areas studied in detail during the cruise are in different water depths and have different geologic controls on the way hydrate is thought to be distributed:

Alaminos Canyon 818-Chevron encountered a thick hydrate-bearing section (20 m) a few hundred meters below seafloor in an exploration well on this block, with high resistivities (30-40 Ohm-m) evident in the logs (see Smith *et al.*, *Fire in the Ice*, Fall 2006). Water depth is around 3,000 m, which is deep for exploration but easily within the 6,000 m operating depth of our equipment. Initially we were hoping to impact future Joint Industry Project (JIP) drilling plans, but shortly before the cruise we heard that AC 818 was dropped from the JIP program. However, as one of the few locations with gas hydrate at high saturations in sands confirmed in a high quality well log data set, this area remained the highest priority for our own studies. We deployed 30 receivers and made four transmission tows, centered on the Chevron well location. Two instruments failed to record data.

Mississippi Canyon 118-This block has been designated as a Minerals Management Services observatory. Large outcrops of hydrate occur on the seafloor in relatively shallow water depths of 800-900 m, but there is yet no direct evidence of hydrate at depth. This area provides the opportunity to coordinate and collaborate with many other ongoing scientific programs, including shallow resistivity surveying. We deployed 24 receivers in a 6 x 4 array and towed 10 transmitter lines in a grid pattern (avoiding the already installed seafloor equipment). All receivers recorded data.

Green Canyon 955-This prospect is in intermediate water depth (2200 m) and shows evidence of gas and gas hydrate accumulation in channel sands near the base of the hydrate stability field (see Hutchinson *et al.*, 2008). GC

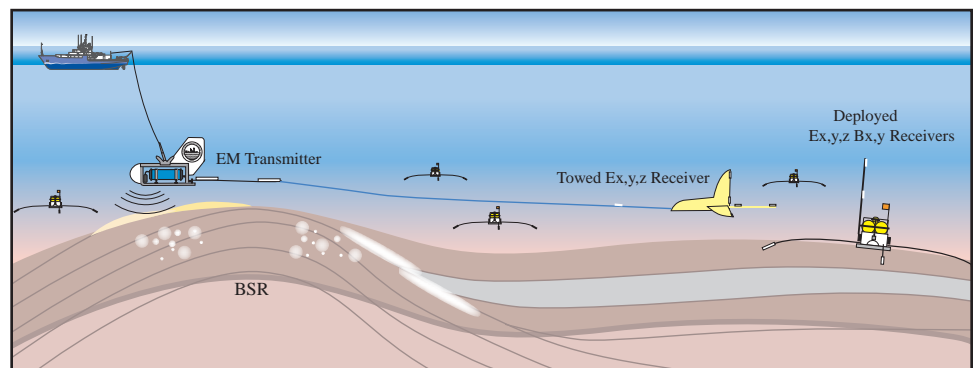


Figure 2: Schematic of survey equipment operation.

FURTHER READING

Weitemeyer, K., S. Constable, and K. Key, 2006. Marine EM techniques for gas-hydrate and hazard mitigation. *The Leading Edge*, 25, 629–632.

Hutchinson, *et al.*, 2008, Site selection for DOE/JIP gas hydrate drilling in the northern Gulf of Mexico., 6th International Conference on Gas Hydrates, Proceedings.

Gulf of Mexico cruise website: <http://marineemlab.ucsd.edu/Projects/GoMHydrate/>

ACKNOWLEDGMENTS

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955 is a priority site for 2009 drilling by the JIP program. Unfortunately, current exploration drilling prevented us from carrying out our survey as originally planned. Nonetheless, we were able to deploy 20 seafloor instruments (all of which collected data) along two lines that pass very close to the primary targets for the JIP drilling.

Walker Ridge 313-This fourth prospect was added at the request of NETL to the 3 sites above selected in consultation with our industry sponsors. It is in intermediate water depths on the lower slope of the northern Gulf of Mexico, within a tabular salt minibasin province and having a very low geothermal gradient (hence a very thick gas hydrate stability zone). Evidence for hydrate comes from seismic data, gas mounds, and focused fluid expulsion sites (see Hutchinson *et al.*, 2008). WR 313 is a priority site for 2009 JIP drilling, so clearly it is desirable to have marine EM data for comparison with the drilling results. We decided that if we had cooperative weather (we did) and scaled back the GC 955 survey by a few sites it would be possible to carry out a two-line survey similar to the one at Green Canyon. These lines pass directly over the permitted JIP drilling sites. Again, we had 100% data recovery.



Figure 3: Deck of R.V. Roger Revelle showing instruments used for this survey.

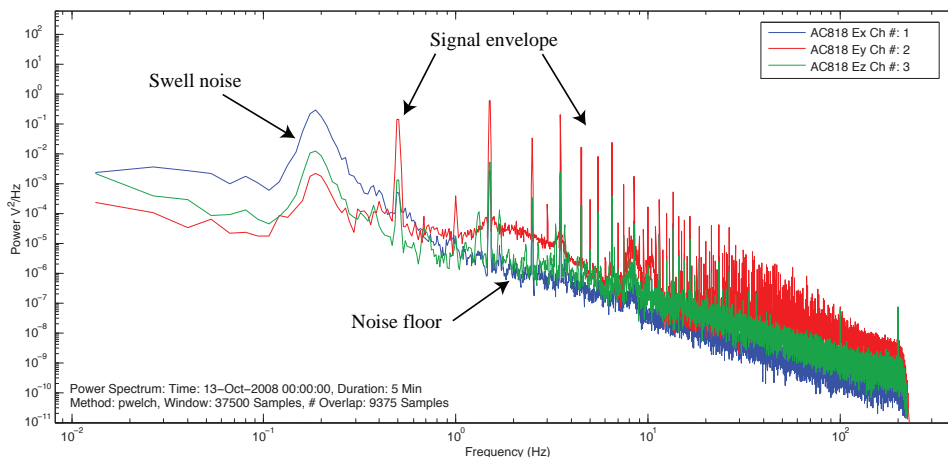


Figure 4: Spectrum of signals recorded on towed receiver Vulcan.