U. S. Geological Survey Gas Hydrate Studies in the Northern Gulf Of Mexico

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Gas hydrates in continental margin sediments are known or inferred worldwide, but are only well-studied and characterized in a few locations. In the Gulf of Mexico, gas hydrates have been identified as abundant surface mounds in much of the north-central Gulf, but evidence is essentially lacking for their existence deeper in the uppermost few hundred meters of sediment where they are expected to be stable. Much of the current interest in the Gulf of Mexico comes from the economic reality that conventional hydrocarbon exploration is moving into frontier deep-water areas, i.e., in regions where drilling will in all likelihood encounter and penetrate potential gas hydrate accumulations. Federal, academic, and industry efforts are converging in the Gulf to make it one of the best studied and characterized sites of hydrate occurrence.

The US Geological Survey (USGS) program in the Gulf of Mexico has dual purposes: (1) to understand the relationships among gas hydrate occurrence, geologic framework, and active geologic processes; and (2) to integrate project results with extensive research that is being conducted by academic institutions and the exploration industry to find the answers to these fundamental questions regarding natural gas hydrate occurrence in the Gulf of Mexico. The initial phase of the USGS project has focused on three areas of the north-central Gulf where gas hydrates and active gas venting are well-known sea-floor features: the Mississippi Canyon, Green Canyon, and Garden Banks. These locations contain diverse geologic features (such as salt domes, deep faults, buried channels, and turbidite deposits) and evidence for active geologic processes (such as mass wasting, slumps, shallow-water flows, young faults, and fluid/gas venting). These settings offer a representative sampling of the complex environments in which to compare and understand gas hydrate occurrence.

Two geophysical cruises in 1998 and 1999 collected more than 1600 km of two-dimensional high-resolution seismic reflection data to image the subsurface gas hydrate stability zone. The primary data sets acquired during these two cruises were: (1) single-channel deep-tow boomer (Huntec) profiles with penetration of greater than 150 meters and 0.25 m vertical resolution (frequency bandwidth approximately 1000-3000 Hz); and (2) 12-fold high-resolution data acquired using a 24-channel 250 meter streamer and either a 15 cu. in. water gun or a 35 cu. in. air gun (high-resolution MCS). The high-resolution MCS can image to up to 2 km sub-seafloor with better than 4 meter vertical resolution, 5 meter horizontal spacing and a 50 to 250 Hz frequency bandwidth. The first cruise, in April 1998, was in collaboration with the University of Mississippi and

surveyed two sites on the banks of the Mississippi Canyon. Both seismic types were collected independently. In June 1999, the second survey was run in the Garden Banks-Green Canyon area with concurrent data acquisition of the above data types along most tracklines. .

The processed data were interpreted for evidence of gas hydrate. The most common seismic indicator of gas hydrate, a bottom simulating reflection (BSR), is rarely observed. One exception is a BSR we interpret on a Garden Banks high-resolution profile in 600 m of water at approximately 160 to 180 m sub-seafloor. Another common indicator, "seismic blanking" (in which seismic amplitudes are dimmed or reduced in the hydrate stability zone), is ambiguous in the USGS seismic data. Bright spots, or uncommonly high-amplitude reflections, are sometimes used to indicate trapped free gas. High-reflectivity zones are observed in the Gulf of Mexico data within the upper sedimentary section that includes the hydrate stability zone, but their distribution and depth cannot now be related uniquely to the presence of gas hydrates. Additional features, such as shallow faults and low-amplitude vertical zones (commonly called chimneys), are likely to be related to fluid and gas flow that may also be associated with hydrates. A complicating situation in the Gulf of Mexico that may obscure the evidence is the large variability of geothermal gradients and the presence of gases other than methane, which alter the conditions of stability. In general, the USGS data contain possible indicators of gas hydrate in the subsurface sediments, but the evidence is equivocal.

To further understand the nature of the subsurface distribution of hydrates, the USGS, with numerous collaborators, including the Department of Energy and the Monterey Bay Aquarium Research Institute, plans to collect 22 giant piston cores up to 50 meters in length in July, 2002, using the French research vessel Marion Dufresne. The core sites are grouped in five transects that are located in each of the three locations (Mississippi Canyon, Green Canyon, and Garden Banks) and will sample targets defined using the seismic data. Geochemical and physical property measurements will help determine indicators for the presence of gas hydrate. With these results, it should be possible to begin to integrate the seismic and sampling results to gain a more complete understanding of the subsurface distributions and occurrences of gas hydrate in the north central Gulf of Mexico.