Monday, April 5, 2010

Westchase Hilton • 9999 Westheimer
Social Hour 5:30–6:30 p.m.
Dinner 6:30–7:30 p.m.

Cost: $28 Preregistered members; $35 non-members & walk-ups

To guarantee a seat, you must pre-register on the HGS website and pre-pay with a credit card.
Pre-registration without payment will not be accepted.
You may still walk up and pay at the door, if extra seats are available.

Dan McConnell, *AOA Geophysics;* ***Ray Boswell,*** *U.S. Department of Energy;* ***Timothy S. Collett,*** *U.S. Geological Survey;* ***Matthew Frye and William Shedd,*** *Minerals Management Service;* ***Stefan Mrozewski, Gilles Guerin, and Ann Cook,*** *Columbia University;* ***Dianna Shelander and Jianchun Dai,*** *Schlumberger;* ***Paul Godfriaux and Rebecca Dufrene,*** *Minerals Management Service;* ***Emrys Jones and Rana Roy,*** *Chevron*

The Discovery of Rich Gas Hydrate Accumulations in Sand Reservoirs in the Gulf of Mexico – Results from DOE-Chevron Joint Industry Project Drilling

In April and May of 2009 the Gulf of Mexico Gas Hydrate Joint Industry Project realized its second field program (Leg II) with the semi-submersible Helix Q4000 drillship. The three-week, $11.5MM expedition drilled seven logging-while-drilling (LWD) holes at three sites to test a variety of geologic/geophysical models for the occurrence of gas hydrate in sand reservoirs in the deep-water Gulf of Mexico. Over 17,000 ft of sedimentary section were logged using a state-of-the-art bottom-hole assembly. The three sites drilled were Walker Ridge (WR) Block 313, Green Canyon (GC) Block 955, and Alaminos Canyon (AC) Block 21. The program was completed on-time and under budget. The locations for JIP Leg II drilling were the result of an integrated geological and geophysical prospecting approach that considered direct geophysical evidence for gas hydrate-bearing strata in the context of evaluation of indicators for gas sourcing, gas migration pathways to the shallow section, and occurrence of sand reservoirs within the gas hydrate stability zone. High saturation gas hydrate

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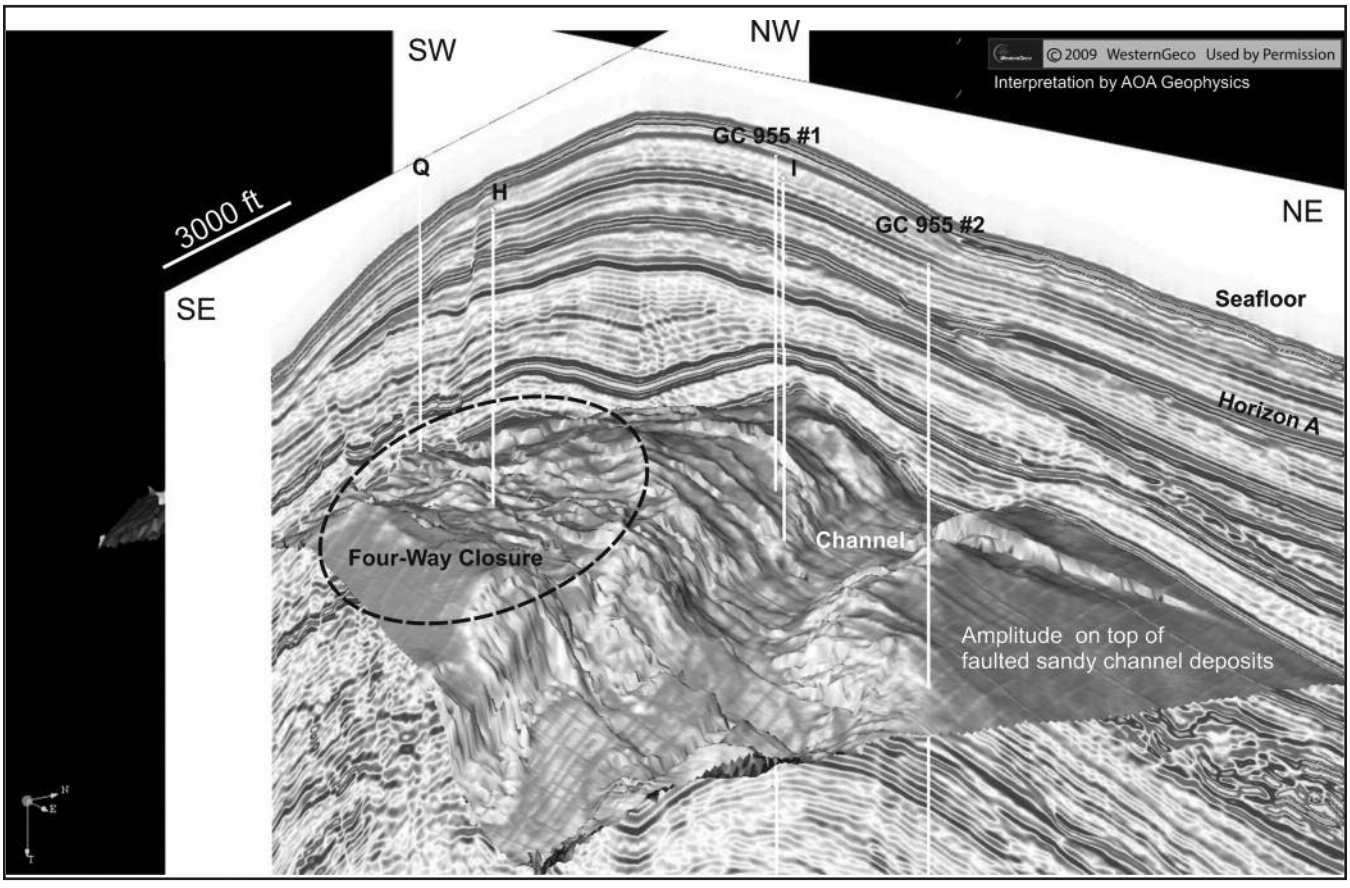

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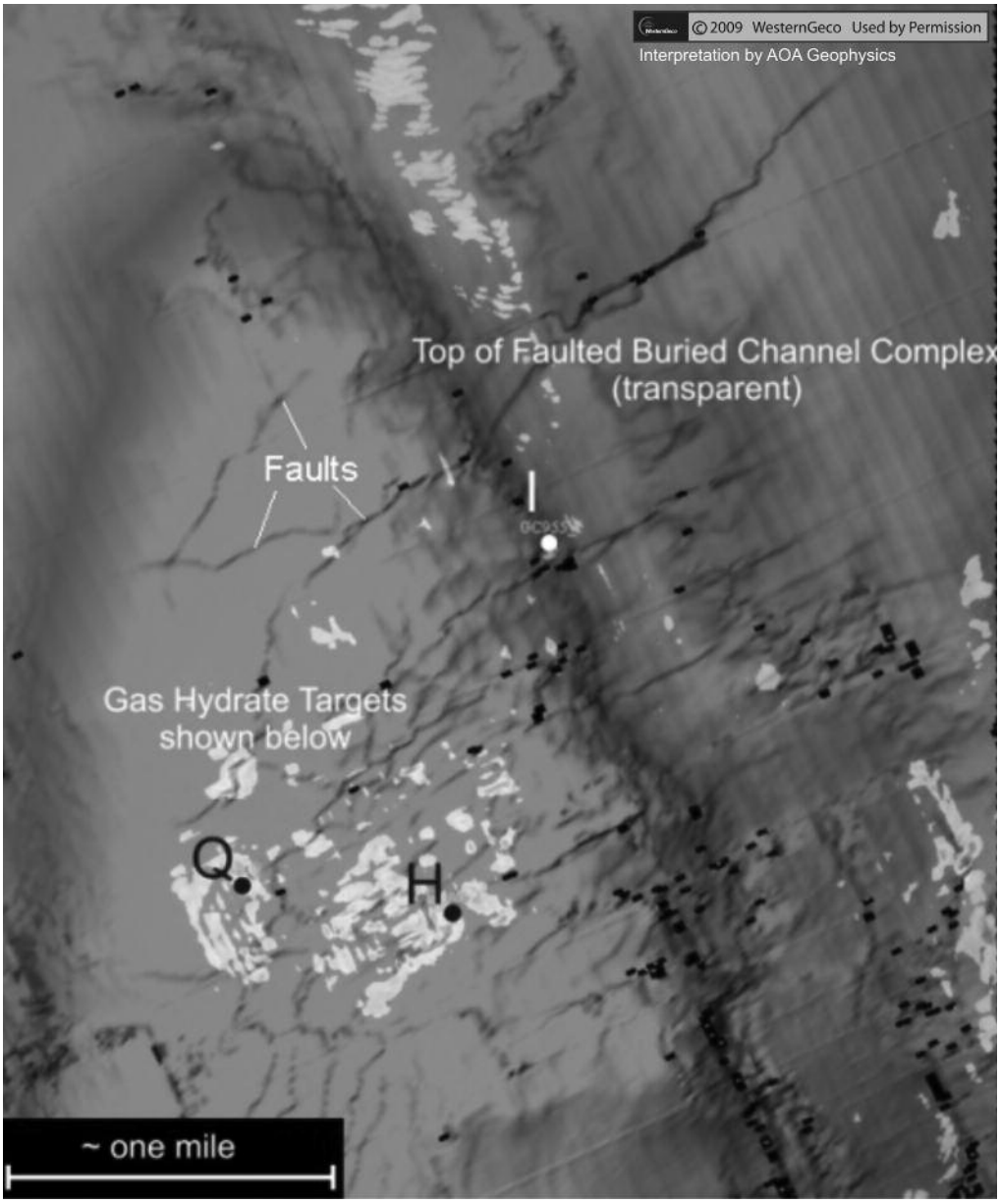

deposits in sands were found, where predicted, in four of five holes at two sites, WR 313 and GC 955. The third site, AC 21, indicated low to moderate gas hydrate saturation in extensive shallow sands. The full research-level LWD assembly deployed for Leg II collected gamma-ray, neutron and density porosity, neutron spectroscopy data, as well as full azimuthal resistivity and acoustic velocity, including both compressional and shear-wave measurements.

Leg II was clearly a high-risk proposition, despite the drilling of a large number of industry wells in the deepwater Gulf of Mexico, there had been only one prior instance (at Alaminos Canyon Block 818) in which gas hydrate had been reported to occur in sand. Nonetheless, the potential for gas hydrate at high saturation in sands was large; an assessment conducted under the leadership of the Minerals Management Service produced a mean estimate of 6,700 tcf gas-in-place in gas hydrate-bearing sands in the deepwater Gulf of Mexico. Perhaps the primary scientific objective of the Leg II program was to provide ground truth data to test the soundness of the prospecting techniques developed with the JIPs site selection team. One part of this approach was pre-drill inversions of seismic data to estimate areal variations in gas hydrate saturation.

The two wells in WR 313, in the Terrebonne Basin, confirmed the pre-drill models. The main gas hydrate targets were approximately 2,700 ft below the seafloor. The first well, WR 313 G, had a predrill prediction of 57% gas hydrate in the target sand. LWD indicated a net of ~30 ft of sand containing gas hydrate with a saturation of 70% at the target horizon. The second well approximately 0.6 miles east and updip, WR 313 H, tested a similar but stratigraphically deeper target. The pre-drill saturation was 53% at the primary target. Results show two lobes of very clean sand with over 90% gas hydrate saturation in the upper lobe. Saturations in the lower lobe ranged from 50% to 60%. In addition, both holes revealed a shallow unit with 350-500 ft of grain-displacing fracture filling gas hydrate in clays beginning approximately 600 ft below the sea floor.

Three holes were drilled in GC Block 955 just outboard of the Sigsbee Escarpment, where a wide and thick late Pleistocene channel complex has been fractured and uplifted by a shallow salt stock. A highly faulted four-way closure with numerous amplitude anomalies at the base of gas hydrate stability is near to but west of the channel axis. The first well GC 955 I was closest to an industry well that penetrated thick sands. As expected, the "I" well encountered a thick sand section but the

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sands contained primarily water with only a few feet of potential gas hydrate.

The next two wells, GC 955 H and GC 955 Q, targeted the sand at the four-way closure approximately 0.7 miles proximal to the youngest well-preserved channel axis in the depositional sequence. The LWD data obtained at this location indicate over 100 ft of gas-hydrate-bearing zones within a single sand-rich unit with saturations estimated to be over 70%. This accumulation is overlain and underlain by, and most surprisingly, interbedded with gas-hydrate-free, water-bearing sands. In addition to the gas hydrate in the target sand, fracture fill gas hydrate was detected in the clay-prone section above the target. GC 955 Q is believed to have encountered at least 50 ft of highly saturated gas hydrate sand at the target, but drilling was aborted because of a potential gas hydrate dissociation event and subsequent gas flow. The LWD data, however, show complex acoustic responses and are still being analyzed before a confident interpretation of the pore fill in the drilled interval can be offered. However, it appears that gas hydrate occurrence, at the GC 955 site is highly complex, both in the sands and in the overlying clays, and is potentially complicated by fault-controlled compartmentalization and related lateral variations in gas delivery, thermal gradients, pore-water salinities, and other phenomena.

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The two wells drilled in Alaminos Canyon Block 21 (AC21), in the vicinity of the Diana Field development, confirmed the pre-drill prediction of potential extensive occurrence of gas hydrates in shallow sand reservoirs at relatively low (<40%) saturations. However, further sample collection and analyses at AC-21 are needed to confirm the existence and quantity of gas hydrate.

The expedition demonstrated the ability to reasonably predict gas hydrate occurrence through seismic data in the absence of pre-drill well data. At WR313, the model linking aligned phase reversals at multiple levels with gas-hydrate bearing sands at the base of gas hydrate stability (BGHS) was confirmed. Furthermore, initial results suggest that gas hydrate has the potential to fully saturate reservoirs well above the BGHS, with the primary control being occurrence of reservoir quality facies. In addition, unexpected findings, such as the complex nature of the gas hydrate occurrence at GC Block 955 and the discovery of the extensive, strata-bound shallow hydrate occurrence at WR Block 313, raise exciting new questions.

The DOE and the JIP are committed to making these data publically available as soon as possible to support a wide range of scientific studies. The initial reports will be published shortly at http://www.netl.doe.gov/MethaneHydrates/JIPLegII-IR/ ■

Biographical Sketch

Dan McConnell began his geoscience career with Scott-Pickford, a British geoscience consulting group. He began to focus on marine geology and geophysics when he joined Fugro-McClelland Marine Geosciences in Houston. There, he interpreted offshore high-resolution surveys and geochemical and geotechnical data in support of offshore engineering and drilling operations. In 2003, Mr. McConnell joined AOA Geophysics to start a Houston-based geohazard consulting group which would augment AOA's seafloor mapping and frontier prospectivity survey business. He is Vice President of AOA Geophysics and manages operations for offshore data acquisition, interpretation, and reporting. Dan holds two degrees, in history and geology, from the University of Texas.