Three-Dimensional Structure and Physical Properties of a Methane Hydrate Deposit and Methane Gas Reservoir, Blake Ridge

W. Steven Holbrook (U. Wyoming), Ingo A. Pecher (UTIG)
National Science Foundation, 4/1/00-9/30/02

PROJECT SUMMARY
Gas hydrate, an ice-like crystalline solid of water and low-molecular-weight gas, appears to be widespread on continental margins and constitutes an enormous reservoir of methane in shallow marine sediments. Hydrates and the underlying zone of free gas bubbles are important for several reasons: they may form a future fossil fuel reserve; they may affect the shear strength, diagenesis, and lithification of marine sediments; and they may play a role in the global carbon cycle and climate change. At present, the lateral variability and dynamics of the methane hydrate/gas system are poorly understood.
A major step forward in understanding the local amount and distribution of hydrate and free gas on the Blake Ridge, offshore South Carolina, occurred in 1995 with ODP Leg 164, which produced quantitative measurements of in situ hydrate and gas concentrations. Several surprising observations came out of Leg 164, including: (1) a lateral increase in hydrate concentration toward the

crest of the Blake Ridge; (2) the free gas zone beneath the bottom-simulating reflector (BSR) is thick (at least 250 m), and (3) shear waves converted at the BSR were recorded on the horizontal component of an ocean-bottom seismometer.

We wish to capitalize on the success of Leg 164 by obtaining new seismic data that will enable us to extend information from the drilling transect into a three-dimensional context. We propose a field program aboard R/V Ewing to obtain two related seismic data sets: (1) the first-ever three-dimensional image of a continental margin hydrate/gas deposit, and (2) the first dedicated study of P-to-S converted waves in a hydrate province. The resulting seismic information, when combined with the chemical, sedimentological, and downhole logging information from Leg 164, will constitute a rare opportunity to establish benchmark linkages between seismic signatures (reflectivity, P-velocity, S-velocity) and the amounts and distribution of hydrate and free gas. In addition, this data set will provide basic 3D geometries of stratigraphy, structures, hydrate concentration, and gas accumulations over a 250 km2 area. The Blake Ridge is an ideal setting for the proposed project, because of (1) the wealth of existing geological, chemical, and geophysical data in the area, and (2) the homogeneous lithology of the sediments, which provide an ideal tabula rasa against which anomalous geophysical properties can be interpreted in terms of hydrate and free gas concentrations. The information provided by this experiment will help constrain several key processes that occur in gas hydrate provinces, including methanogenesis, hydrate formation and decomposition, and the migration of free gas.

The UTIG part of this project focusses on the analysis of P-to-S converted waves, which were first observed during Leg 164:

Blake Ridge Gas Hydrates - Converted Shear Waves

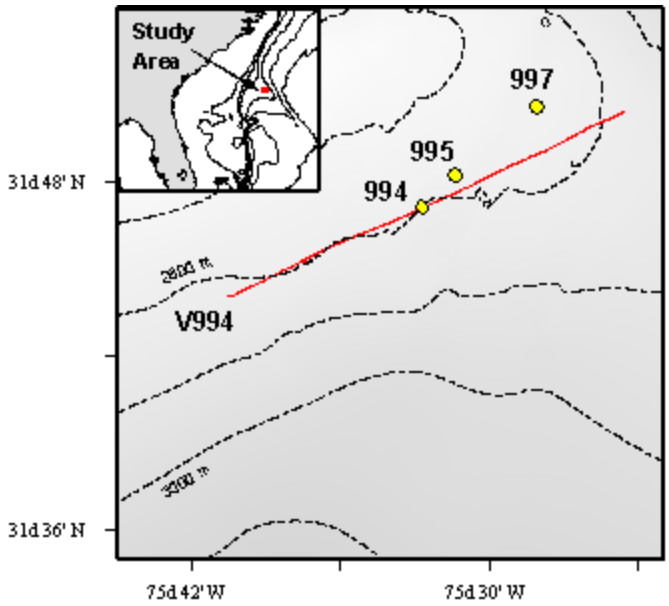

Fig. 1: Location of the combined walkaway-VSP/OBS survey. Numbers mark ODP Leg 164 boreholes.

A combined walkaway vertical seismic profiling (VSP) and ocean bottom seismometer (OBS) survey was conducted in 1995 in conjunction with Ocean Drilling Program (ODP) Leg 164 on the Blake Ridge. A 14 km-long airgun profile was shot from the *R/V Cape Hatteras* across ODP Site 994 and was recorded with a three-component geophone in the borehole. After drilling, OBSs were deployed and a 26 km shooting profile was recorded.

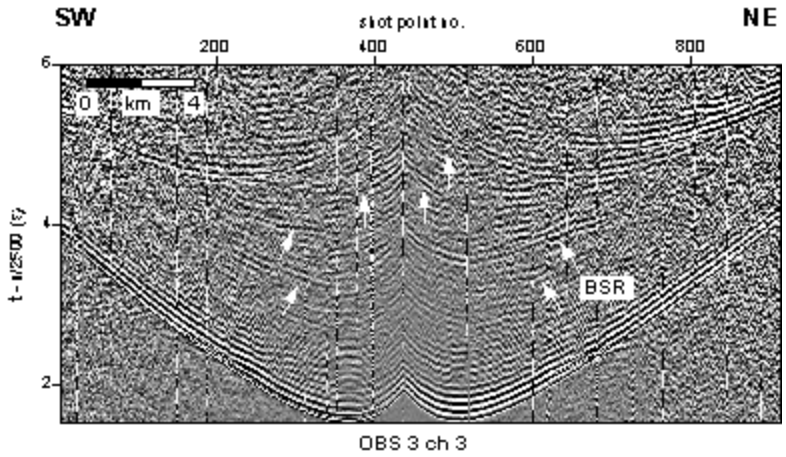

Fig. 2: Horizontal component of OBS at Site 994. Arrows: converted waves. "BSR" is converted at or near the BSR (from Pecher et al., 1997).

We identified converted shear (S-) waves in the horizontal components of both the VSP tool and OBSs (fig. 2). We are currently re-analyzing S-wave velocities taking into account the recent observation of P-wave anisotropy. We are hoping to conduct a converted S-wave survey on the Blake Ridge during a cruise schedule for Sept./Oct. of 2000 (3D Multichannel Seismic Project).

Related sites:

- Steve Holbrook's Gas Hydrate Research: ODP Leg 164
- Cruise Report *R/V Cape Hatteras*18-95

contact webmaster
UT Institute for Geophysics
4412 Spicewood Springs Rd. #600
Austin, TX 78759-8500 USA
Phone: 512-471-6156
Fax: 512-471-8844
Map to UTIG
Last modified: 28 Aug 2001 09:02