August 20, 2001

The University of Texas Institute for Geophysics

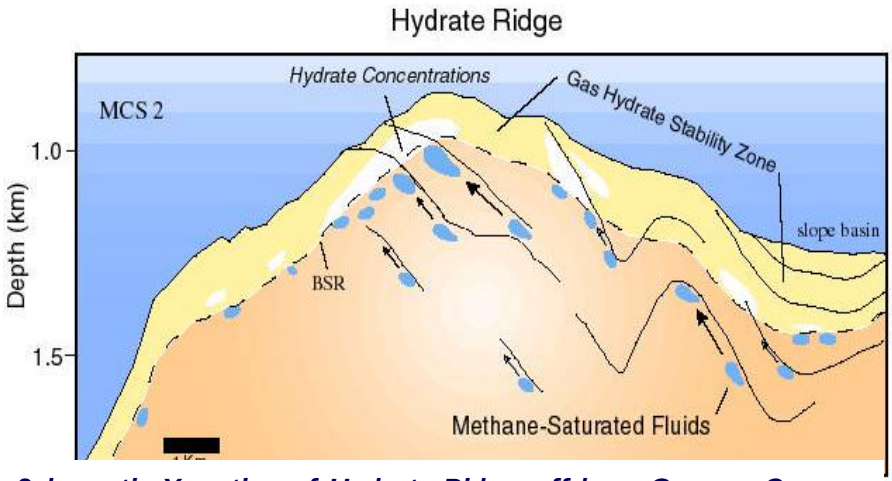
Principal Investigators

Nathan Bangs Mrinal Sen & Yosio Nakamura

A SEISMIC INVESTIGATION OF GAS HYDRATE ACCUMULATION ALONG THE OREGON CONVERGENT MARGIN

GAS HYDRATE, a potentially important hydrocarbon resource, is an ice-like substance that forms in the upper few hundred meters of seafloor sediments under specific temperatures and pressure. The dominant gas is methane, which is produced through the decomposition of organic matter. Gas hydrate often occurs along convergent margins where there is a high fluid and methane flux out of the accretionary wedge. In the summer of 2000, scientists at the University of Texas Institute for Geophysics, Oregon State University, and Columbia University conducted a high-resolution seismic reflection and refraction survey of one such convergent margin setting—Hydrate Ridge, offshore Oregon.

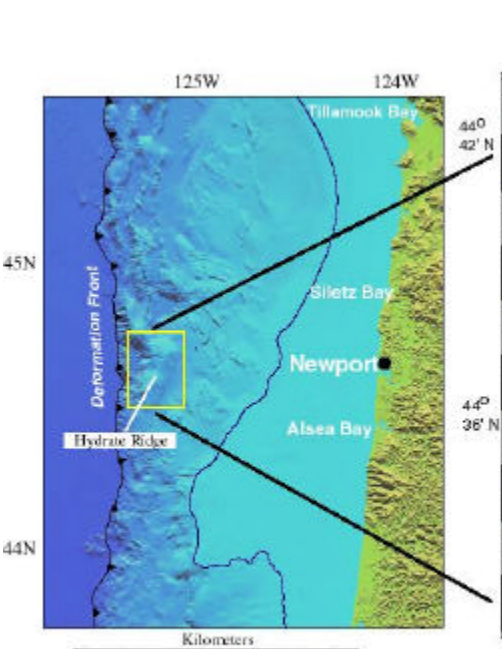
Gas hydrate is an ice-like substance composed of rigid cages of water molecules that enclose a low molecular weight gas—mainly methane (CH4)



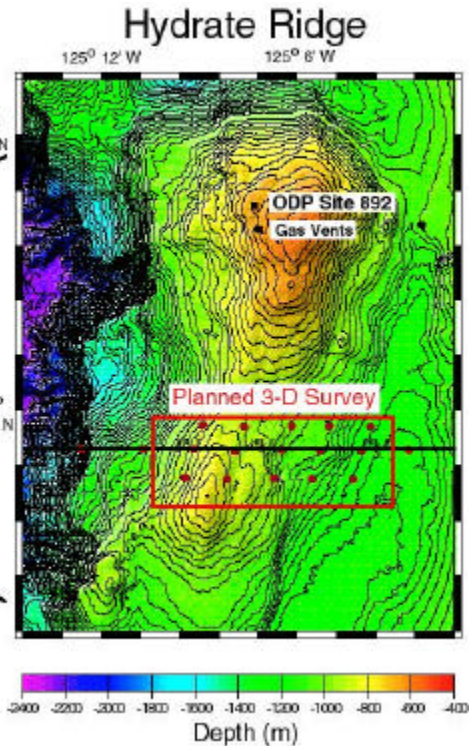
Schematic X-section of Hydrate Ridge, offshore Oregon. Concentrations of gas hydrates are in the upper seafloor sediments.

GEOLOGIC SETTING. Hydrate Ridge, forms along a convergent margin from the collision of the Juan de Fuca oceanic crustal plate and the North American plate. It is the second frontal ridge of the accretionary wedge that formed from folded and thrust sediments initially deposited on the subducting Juan de Fuca plate. Evidence of concentrated hydrate accumulations broadly distributed across the ridge include the following: (1) direct observations of hydrate outcrops on the seafloor sampled during Alvin dives on southern Hydrate Ridge; (2) bright side-scan reflections from the seafloor near hydrate outcroppings that suggest a broad distribution of hydrates at or near the seafloor; (3) numerous gas seeps and pock marks observed during submersible dives and from seafloor mapping; and (4) the recovery of gas hydrate from cores near fault zones on Leg 146 at Site 892 on northern Hydrate Ridge. Southern Hydrate ridge may have more broadly distributed hydrates because of the subsurface plumbing system, which is believed to be much more focused along faults in the north, and more focused within landward dipping stratigraphic horizons that comprise southern Hydrate Ridge.

SCIENTIFIC OBJECTIVES. In order to characterize the regional pattern of fluid and gas migration, and its relationship to hydrate accumulations on Hydrate Ridge, an NSF-sponsored marine



Hydrate Ridge lies about 60 miles west of Newport, Oregon, 10 km east of the deformation front of the Cascadia subduction zone.



Hydrate Ridge is prominent ridge created by thrusting within the accretionary wedge. A 4 x 10 km 3-D survey high-resolution seismic survey with 50 m line spacing (red box), and acquisition of 21 OBSs.

geophysical seismic program was conducted during summer 2000 on board the *R/V Thompson.* The seismic program involved a 3-D seismic reflection survey and a seismic refraction experiment.

The 3-D data acquired with the Lamont-Doherty high-resolution seismic acquisition system (48 channel, 600 meter, ITI streamer and OYO-DAS recorder) yielded detailed images of both the deformed stratigraphy and fault systems of the accretionary wedge, and the stratigraphy of the slope sediments deposited on the accretionary wedge. Variations in seismic reflection amplitudes revealed variations in fluid and free gas accumulations. The 3-D data, in conjunction with other structural details, will be used to map the plumbing system of this high fluid flux setting. Twenty-one of UTIG's ocean bottom seismographs (OBS) were deployed before beginning the 3-D seismic survey for the acquisition of seismic refraction data. Seismic refraction data acquired from shots fired from two GI air guns towed at two meters below the sea surface were recorded on the OBSs to help map out both free gas accumulations beneath the hydrate stability zone and hydrate accumulations within it. Horizontal geophones show slow arrival times that are identified as converted shear waves. A detailed analysis of the multi-component OBS data are currently being carried out under the direction of Mrinal Sen. This will help estimate shear wave velocities from different observations—an important parameter in the quantification of the gas content.

RELEVANCE. Global estimates of gas hydrates place the total amount of carbon locked up in gas hydrates at twice the amount of all the rest of Earth's other hydrocarbons combined. This potential hydrocarbon resource, the effects on global climate from release of methane trapped in gas hydrates (methane is a greenhouse gas), and the role of hydrates as a catalyst for seafloor slope instability have sparked new efforts to understand the occurrence and distribution of gas hydrates in the shallow seafloor sediments. The results of this study will provide site survey data for locating the drill sites for ODP Leg 204 in summer 2002. Leg 204 will directly sample hydrates and quantify hydrate and free gas accumulations within a variety of structural settings across southern Hydrate Ridge.

EDUCATION AND TRAINING. This seismic investigation provided opportunities for graduate students to conduct research and to participate in the fieldwork Students continue be involved in processing the data and interpreting the results.

COLLABORATION. The Hydrate Ridge seismic study is a collaborative effort involving scientists and students at UTIG, Oregon State University, and Columbia University. Funding is from the U.S. National Science Foundation.

CONTACT DETAILS

- **Nathan Bangs (nathan@ig.utexas.edu)**
- **Mrinal Sen (mrinal@ig.utexas.edu)**
- **Yosio Nakamura (yosio@ig.utexas.edu)**

The University of Texas Institute for Geophysics
4412 Spicewood Springs Rd., Building 600
Austin, TX 78759

UTIG (www.ig.utexas.edu)