NOAA Office of Ocean Exploration Quick Look Report

Expedition Title: Windows to the Deep: Exploring the Blake Ridge

Results (please check all disciplines in which this cruise collected data)	**Details** (please describe any novel discoveries in the discipline, answers such as "possible, awaiting data analysis" and "no apparent discoveries" are acceptable)
Bathymetric Mapping **x** Yes ☐ No	(please note total area mapped and technology employed, e.g. multibeam, side scan, etc.) Multibeam bathymetry and 3.5 kHz subbottom profiling of Blake Ridge diapir, Cape Fear diapir, and northeastern eroded flank of Blake Ridge
New Species Discovered ☐ Yes ☐ No	(please note number, type, and significance ,i.e. radically new vs. slight adaptation of known species) Species identification will take many months or up to a year
Bio-prospecting ☐ Yes **x** No	(please note number, type, and potential use of new compounds discovered)
Habitat Range Extended ☐ Yes **x** No	(please note species discovered in new habitats and how far from previous range were they found0
Chemical Processes **x** Yes ☐ No	(please note new or unusual chemical properties such as methane seeps, hypersaline pools, vents, etc. observed) Cold seeps: Acquired pore water samples at high resolution in push cores for later sulfate, sulfide, and methane analyses and for stable sulfur isotopic analyses. Obtained carbonate samples for carbon isotope analyses.
Geologic Processes **x** Yes ☐ No	(please note new or unusual geologic processes that may impact scientific understanding of the region) Significant new map of Cape Fear submarine slide and preliminary identification of new structural features that interact directly with the gas hydrate reservoir. Revisited areas previously mapped as loci of shallow free gas, leading to a reassessment of their free gas potential. New maps of diapirs inboard of Carolina Trough.
Physical Processes **x** Yes ☐ No	(please note new or unusual oceanographic processes that may impact scientific understanding of the region) Acquired CTD data that can later be used in conjunction with traditional seismic data in delineating the 3D thermal structure of the ocean.
Sub/ROV/AUV Dives **x** Yes ☐ No	(please note name, type, and cumulative hours of bottom time for each platform / if available please provide average working time per dive for each platform / please note if new depth records were set) 7 Alvin dives, averaging approximately 5 hours of bottom time per dive; depths of 2157 to 3456 meters;
New Technology ☐ Yes **x** No	(please note any new tools developed for or during this cruise, also identify first use of an existing technology in a new application)
Maritime Cultural Heritage ☐ Yes **x** No	(please note discoveries impacting knowledge of the past, i.e. number and type of shipwrecks)
Outreach **x** Yes ☐ No	(please describe outreach channels, e.g. web, port call, etc., used in this project) K-12 outreach through lesson plans developed by OE/Keener-Chavis and participation of Georgia COSEE office head; 16 of 20 non-OE members of the science party were current or just-graduated undergraduate or graduate students and 11 of these students were able to dive in Alvin; outreach through OE website and through publicity offices at universities of participants; one participant from HBCU
Students Involved **x** Yes ☐ No	(please note the number and level of students on the expedition) 16 just graduated or currently enrolled students: 3 current undergraduates, 3 just graduated students, 1 just graduated MS student, 4 Master's students, and 5 PhD students
Multidisciplinary **x** Yes ☐ No	(please identify the formal disciplines represented in the science party) geochemistry, seep ecology, microbiology, geophysics
Exploration of New Regions **x** Yes ☐ No	(please note if the area of operations had been previously studied, if so please check no and approximate as slight, moderate or significant, the level of knowledge before the cruise) New seafloor exploration of Cape Fear diapir, Cape Fear slide escarpment, and Blake Ridge proper

Project Title: Windows to the Deep: Biological sampling and high-resolution mapping at methane seeps on the Blake Ridge and Carolina Rise

Principal Investigator: Dr. Carolyn Ruppel, Georgia Institute of Technology

Expedition Title: Windows to the Deep

Expedition Dates: 22 July – 3 August, Woods Hole MA to Woods Hole MA

Chief Scientist: Dr. Carolyn Ruppel, Georgia Institute of Technology

PIs and Participating Organizations: Co-Chief Scientist CL Van Dover, The College of William & Mary; S Holbrook, University of Wyoming

Other institutions represented: University of Virginia; Savannah State University; Massachusetts Institute of Technology; Joint Oceanographic Institutions, Inc.;

Vessel: R/V Atlantis

Embarked vehicles: Alvin (7 dives)

Geographic area of operations: Blake Ridge and Carolina Rise; Boundary coordinates:

Summary of cruise objectives:
Objectives of Windows to the Deep included compilation of biotic inventories and descriptions of seep environments of the Blake Ridge, high-resolution mapping and sub-seafloor profiling of prominent seafloor features associated with seafloor expression of methane flux, and ground-truthing of these features with submersible operations.

Summary of cruise operations:

Alvin Dives: 7 dives completed; total bottom time: 34:40 h; depth range: 2157-3456 m; number of scientists as observers: 13, including 8 graduate students, 3 undergraduate students

DIVE	DATE	LOCATION	PRIMARY OBJECTIVE
3908	25 July 03	Blake Ridge Depression	Characterize seafloor expression of subsurface gas chimneys and other features related to escape of methane from the seabed
3909	26 July 03	Blake Ridge Diapir	Pushcore sediments beneath major megafaunal types in the seep environment for characterization of animal/microbial/porewater chemistry relationships
3910	27 July 03	Blake Ridge Diapir	Pushcore sediments beneath major megafaunal types in the seep environment for characterization of animal/microbial/porewater chemistry relationships
3911	28 July 03	Cape Fear Diapir	Explore top of diapir for cold seep communities and other geological/biological evidence of methane seeps
3912	29 July 03	Blake Ridge Diapir	Pushcore sediments beneath major

			megafaunal types in the seep environment for characterization of animal/microbial/porewater chemistry relationships; determine extent of the seep area
3913	30 July 03	Cape Fear Diapir	Explore transition across a fault, from deposit left by Cape Fear slide to an uplifted area seemingly underlain by shallow free gas
3914	31 July 03	Cape Fear Diapir	Explore the southern side of the Cape Fear Diapir, with particular focus on exploring a canyon close to the depth at which gas should intersect the surface and on surveying a large scale fault that bounds the diapir

Samples collected during Alvin dives

DIVE	Sample Type	Comments
3908	7 push cores	2 cores for dating, 5 cores for background porewater and sediment characterization
	1 rock	carbonate (?) rock with thick secondary alteration rind and some microfossils
3909	24 push cores	6 cores for background porewater and sediment characterization; 3 bacterial mat cores; 3 mussel bed cores; 12 (dead) clam bed cores
	2 bioboxes	2 lots of mussels (healthy and unhealthy) for parasite studies
	3 slurp samples	dead clams, worms
	Niskin bottle	water sample at bottom
	CTD	logged continuously at 10 second intervals
3910	24 push cores	6 bacterial mat cores; 3 cores near hydrates; 16 (live) clam bed cores
	2 bioboxes	2 lots of mussels (healthy and unhealthy) for parasite studies
	5 slurp samples	clams, ice shrimp
	Niskin bottle	water sample at bottom
	CTD	logged continuously at 10 second intervals
3911	2 rocks	clean gray carbonate; mudstone
	CTD	logged continuously at 10 second intervals
3912	24 push cores	3 bacterial mat cores; 3 cores near hydrates; 19 (live) clam bed cores

	1 slurp sample	clams
	1 Niskin	water at seep field
	1 rock	authigenic carbonate boulder from surface
	CTD	logged continuously at 10 seconds
3913	3 push cores	3 cores for dating
	Niskin	One near bottom sample
	CTD	Logged continuously at 10 seconds
3914	7 push cores	3 originally collected for background and 4 from small depressions with discoloration, possibly brine; flocculent material from discolored area removed for DNA and cell counts after squeezing
	2 rocks	Heavily burrowed mudstone from rubble field; Strongly layered beige carbonate with slickensides
	Kevlar scoop	Unlithified, strongly burrowed clean clay from "mud chimneys"
	Niskin	One near bottom sample
	CTD	Logged continuously at 10 second intervals

Night-time-Operations:

The nighttime program consisted of coincident Seabeam and 3.5 kHz subbottom profiling surveys conducted from soon after Alvin arrived on deck following each dive until ~5:30 a.m. local time the next morning. The surveys conducted by the expedition are summarized below.

July 24: Surveyed eroded eastern flank of Blake Ridge along east-west transects mostly coincident with Ewing 2000 multichannel seismic lines

July 25: Transit to Blake Ridge Diapir; 6 crossings of the diapir

July 26: 3D survey of the Blake Ridge Diapir along 24 lines spaced at 40 meters

July 27: Transit to Cape Fear Diapir; surveyed southern diapir with at least 5 crossings near Sites 991 and 992, but primarily 992

July 28: Surveyed outer edges of Cape Fear slide escarpment and transited to Blake Ridge diapir

July 29: Surveyed inner headwall of Cape Fear slide scar, particularly the unconformity

July 30: Intensive, fine-scale mapping of internal structure of north diapir in Cape Fear area and of Cape Fear diapir proper; more mapping of the Cape Fear submarine slide scarp

July 31: Completed mapping of region between Blake Ridge and Cape Fear Diapirs and upper headwall scarp of Cape Fear slide before starting transit to Woods Hole

Milestones:

A. *Toward characterization of animal-sediment-chemistry relationships*. A complete set of samples (including critical background samples) was acquired to determine for the first time the relationship between seafloor flux indicators (clams, mussels, bacterial mat) and shallow subsurface sediment and porewater characteristics at the Blake Ridge seep site. Parameters to be measured in a comprehensive subset push core samples at a down-core interval resolution of 2 cm: animal density, microbial composition, Eh (1-cm resolution), porewater sulfide, sulfate, pyrite, and methane concentrations, grain size, organic content. For clam samples, reproductive condition and parasite burdens will be determined for a select subset of material.

B. *Produced a new map of the Cape Fear submarine slide*. The most complete map ever produced of the Cape Fear submarine slide, the largest on the U.S. East Coast, was compiled using Seabeam and 3.5 kHz surveying. The map significantly revises the placement of major scarps and may lead to a new estimate of the total volume of the slide, which is typically interpreted as having developed as a consequence of slope failure related to the presence of gas hydrates. The data also provide a basis for new interpretations of areas previously delineated as underlain by shallow free gas by previous researchers.

C. *Developed a 3-dimensional image of the Blake Ridge Diapir*. Shallow imaging techniques were used to acquire slices through the Blake Ridge Diapir at very fine spacing. These images reveal the 3-dimensional structure of the gas chimneys that sustain the seep community and constrain the specific faults being exploited by gas and warm fluid fluxing from below.

D. *Developed new criteria for recognition of cold seeps in methane hydrate area*s. Based on new observations at the Blake Ridge Diapir and the lack of new cold seep discoveries at other prime targets for the expedition, new criteria have been devised to predict the location of methane seeps. Among these criteria are: (a) sediment cover; (b) pervasive faulting that taps into deep, hot fluids; (c) a deep source of gas to supplement in situ gas production; (d) features that lead to the development of strong lateral and vertical thermal and chemical gradients.

E. *Possible identification of new structural features.* The survey data are only preliminary, but provide provocative evidence for previously unknown structural features, including basement uplifts, previously unrecognized diapirs(?), new fault scarps related to submarine slides, soft sediment/synsedimentary deformation features, and complex distribution of primary and secondary slide deposits within the Cape Fear slide scar. At the same time, the surveys have yielded the most complete data collected about the three southernmost of the line of diapirs stretching from the Blake Ridge Diapir on the south to the northern Cape Fear diapir on the north.

Summary of Digital Data Collected:

1. DVCAM digital videos logging all on-bottom Alvin activities
2. Seabeam data for multibeam bathymetry
3. 3.5 kHz Knudsen data for subbottom profiling system
4. CTD data for ocean temperature structure studies
5. Other Alvin related data (e.g., navigation)
6. Meteorological sensors, ship's navigation, and water parameters

Summary of Outreach and Educational Activities:

- The three PIs are university professors and engage their students and institutions in expeditionary planning.
- Six undergraduates or recently graduated students joined the expedition: 2 from Georgia Tech, 2 from The College of William & Mary, 1 from MIT, 1 from Savannah State University, and 1 from Brown University (now an intern with Joint Oceanographic Institutions, Inc.). Savannah State University is a HBCU within the University System of Georgia.
- Nine graduate students joined the expedition: 3 from Georgia Tech, 4 from The College of William & Mary, 1 from the University of Wyoming, 1 from the University of Virginia.
- Eleven of the 16 students and recently graduated students who participated in the expedition visited the seafloor in Alvin.

- One of the expedition participants is the head of the Georgia office for the NSF-funded COSEE (Southeast Center for Ocean Science Education Excellence) program, which has as its primary objective outreach to K-12 schools regarding marine science issues.
- The College of William & Mary published journal entries from W&M participants on its web pages, directly linked from the W&M homepage.
- A reporter from the Richmond-Times Dispatch plans to run a feature on the W&M component of the expedition.
- The Georgia Tech publicity office will run an article on the expedition after the cruise.
- Undergraduate students Anne Mills (College of William and Mary) and John Braxton (Savannah State University) will make presentations on their experiences at local high schools during fall semester 2003.
- A link from the OE expedition website to the *Linnaeus Locus* website at William & Mary provided web viewers with a web documentary of the description of a new species collected from the Blake Ridge methane hydrate seep.
- Posters presented expedition results on *R/V Atlantis* during an Open House for WHOI personnel on 4 Aug 03.
- The Ocean Explorer web site was updated with daily logs and images during the expedition.
- Lesson plans were developed by OE.
- During one of the dives, there was a pre-arranged satellite phone conversation between 25 teachers from South Carolina, participating in an OE Professional Development Institute, and an *Alvin* Pilot and two scientist observers.