UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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A SUMMARY OF ENVIRONMENTAL GEOLOGIC STUDIES ON THE SOUTHEASTERN UNITED STATES ATLANTIC OUTER CONTINENTAL SHELF 1977 - 1978

Peter Popenoe

Final report submitted to the
U.S. BUREAU OF LAND MANAGEMENT
under Memorandum of Understanding
AA551-MU8-13

U.S. Geological Survey
Open-File Report 81-583

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards. Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

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Table of Contents

A SUMMARY OF ENVIRONMENTAL GEOLOGIC STUDIES ON THE SOUTHEASTERN UNITED STATES ATLANTIC OUTER CONTINENTAL SHELF 1977 - 1978

Peter Popenoe

INTRODUCTION AND SCOPE

The growing need to find and develop new energy resources has led to increased interest in the petroleum potential of the Atlantic Outer Continental Shelf (OCS). In 1953 the Outer Continental Shelf Lands Act established federal jurisdiction over the OCS area and charged the Secretary of Interior with the responsibility for the administration of the mineral exploration and development of these lands. The Secretary of Interior authorized the Bureau of Land Management (BLM) to lease tracks for resource development. In 1969, the National Environmental Policy Act was passed requiring that all federal agencies utilize a systematic interdisciplinary approach to assess the social and environmental effects of any major federal action, such as the leasing and development of the OCS. The BLM responded to this mandate by instituting and funding Environmental Assessment Teams, marine environmental data acquisition and analyses studies, literature surveys, socio-economic analyses studies, and public conferences and special studies leading to comprehensive Environmental Impact Statements (EIS).

As part of this environmental assessment effort, in 1976 the BLM entered into an agreement with the U.S. Geological Survey (USGS) to undertake geological oceanography studies on the southeastern Atlantic shelf, one of three designated Atlantic OCS target areas for petroleum exploration. The investigations of the southeastern OCS were requested and funded by the BLM Environmental Assessment Division, New Orleans office and were detailed in a Memorandum of Understanding (MOU AA550-MU6-56). Results of the first year and one-half of study, fiscal years 1976 and 1977 (FY-76/77), were released as NTIS report PB300-820 and as two USGS open-file reports (Popenoe, 1980a and b). This summary report covers the second year's studies, the fieldwork for which was conducted during the period 1 October 1977 to 30 September 1978 (FY-78) in accordance with MOU AA551-MU8-13, and the full details of which are published in Popenoe (1980c).

The general purpose of the BLM Environmental Studies Program is 1) to provide information about the OCS environment that will enable the Department and the Bureau to make sound management decisions regarding the development of mineral resources of the federal OCS; 2) acquire information which will enable BLM to answer questions about the impact of oil and gas exploration and development on the marine environment; 3) establish a basis for predicting the impact of oil and gas development activities on frontier areas; and 4) acquire impact data that may result in modification of leasing regulations, operating regulations, or OCS operating orders to permit more efficient resource recovery with maximum environmental protection.

The specific objectives of the USGS-BLM geologic research program for FY-78 were 1) to determine the sedimentation rates and processes on the upper slope and inner Blake Plateau; 2) to determine the distribution, areal extent, and nature of geological features supportive of biological communities; 3) to monitor the transport of bottom sediment across the OCS, evaluate its possible effect on pollution transfer across the seabed and the potential of sediment as a pollution sink, determine the implications of erosion/deposition on pipeline emplacement, and aid the interpretation of chemical, biological, and physical data; 4) to determine the concentration levels of chosen trace metals and silica in three chemically defined fractions of the suspended particulate matter (seston); 5) to study the shelf edge and slope near areas of oil and gas interest, and the northern portion of the Blake Plateau for evidence of slope instability and other geologic hazards; and 6) to determine the depth and rate of sediment mixing caused by large storms and/or benthic organisms and where possible to estimate the rate of active sediment accumulation.

The comprehensive final report (Popenoe, 1980c) summarizes in detail the methods, techniques, instruments, and procedures utilized in accomplishing these objectives, and the results, interpretations, and conclusions based thereon. This report is a brief summary of the larger final report, but in no way covers all of the results of the individual studies. Chapters covering specific objectives are summarized in table 1. Not included in the final report or this summary, however, are the results of a tripod and current-meter study of sediment transport. Fieldwork for this task continued into FY-79 under MOU AA551-MU9-8 and it was deemed desirable to combine the analyses from these two periods of observation into one data synthesis based on the longer period of observation. Accordingly, results of these studies will be reported in the final report under MOU AA551-MU9-8.

RELATION TO BENCHMARK CONTRACTORS

The USGS has maintained communication and cooperation with the contractors for various BLM funded environmental studies at a series of conferences and Administrative Council meetings convened on a quarterly basis by BLM. These meetings have been hosted by Science Applications, Inc. (SAI), the prime contractor for physical oceanography. Attending these meetings were project managers of the various study elements

Table 1. Chapters addressing aspects of specific objectives of the environmental hazards program for FY-78.

Objectives	Chapter 2	Chapter 3	Chapter 4	Chapter 5	Chapter 6	Chapter 7	Chapter 8	Tripod Study
1. Determine the sedimentation rates and processes on the upper slope and inner Blake Plateau.	x		x	x	x			
2. Determine the distribution, areal extent, and nature of geological features supportive of biological communities.				x	x			
3. To monitor the transport of bottom sediment across the OCS.		x				x		x
4. To evaluate the effect of sediment transport on pollution transfer across the seabed.		x	x	x				x
5. To determine the implications of erosion-deposition on pipeline emplacement.		x			x		x	x
6. To determine the concentration levels of chosen trace metals and silica in three chemically defined fractions of the suspended particulate matter.	x							
7. To study the shelf edge and slope and the northern Blake Plateau for evidence of slope instability and other geologic hazards.			x	x			x	
8. To determine the depth and rate of sediment mixing caused by large storms and/or benthic organisms and to estimate the rate of active sediment accumulation.		x	x					x

Table 1. Chapters addressing aspects of specific objectives of the environmetnal hazards program for FY-78. (Continued)

Subobjectives	Chapter 2	3	4	5	6	7	8	Tripod study
A. To geologically map the shallow stratigraphy of the shelf and Blake Plateau as an aid in rig or pipeline placement and aquifer studies.				x	x	x	x	
B. To map the nature and distribution of slumps and other hazards or constraints to petroleum exploration on the slope and Blake Plateau.				x		x	x	

within the BLM program including SAI (physical oceanography and archeological resource studies), NASA (satellite oceanography), NDBO (data buoys), JACOR (model evaluation), and USFWS (ecological studies). Also attending were representatives of the coastal states, North Carolina, South Carolina, Georgia, and Florida; Environmental Protection Agency; Department of Energy; USGS Conservation Division; and other state and federal agencies. During meetings a free exchange of data has taken place and mutual problems have been discussed.

ACKNOWLEDGEMENTS

The investigations reported herein were carried out mainly by personnel of the USGS, Woods Hole, Massachusetts and Raleigh, North Carolina, or by subcontractors at the University of Georgia Skidaway Institute of Oceanography, and the University of South Florida. The principal investigators for each study element, their affiliation, and their contribution to the final report (Popenoe, 1980C) are listed in table 2.

The overall program was managed by Peter Popenoe, USGS. In addition to the principal investigators and other scientists working with them, many other scientists and technical staff members supported the cruises that collected the geological oceanographic data. Special thanks are extended to Nancy Soderberg for the monumental job of typing the final report.

Key personnel of BLM who conceived and supported the environmental geological program and aided in its direction included Tom Ahlfeld, Acting Chief, Branch of Environmental Studies; Paul Lubetkin, Contracting Officer; Ed Wood and Murray Brown, Contracting Officer's Authorized Representatives (COAR); Douglas Elvers, Chief of the New

Table 2. Roles of key participants.

Chapter	Title	Principal investigator	Application
1	Introduction	Peter Popenoe, editor	U.S. Geological Survey Woods Hole, MA 02543
2	Components and pathways of seston flux of the Georgia embayment	Larry J. Doyle	University of South Florida St. Petersburg, FL 33701
3	^{210}Pb in sediment cores from the Atlantic Continental Shelf: estimates of rates of sediment mixing	Michael H. Bothner	U.S. Geological Survey Woods Hole, MA 02543
4	Sediments and sedimentary processes as interpreted from piston cores and grab samples from the continental slope of the southeastern United States	Larry J. Doyle	University of South Florida St. Petersburg, FL 33701
5	Piston core and surficial sediment investigations of the Florida-Hatteras Slope and inner Blake Plateau	Orrin H. Pilkey	U.S. Geological Survey and Duke University Durham, NC 20776
6	Ocean bottom survey of Georgia Bight	Vernon J. Henry, Jr.	University of Georgia Skidaway Institute Savannah, GA 31406
7	Seismic stratigraphy of the northern and central Blake Plateau	Peter Popenoe	U.S. Geological Survey Woods Hole, MA 02543
8	As assessment of potential geologic hazards of the northern and central Blake Plateau	Peter Popenoe	U.S. Geological Survey Woods Hole, MA 02543

Orleans Office Environmental Assessment Division; and Jesse L. Hunt, Project Inspector.

FIELDWORK

Table 3 summarizes cruise data, samples taken, and observations made on USGS-BLM cruises. Field data were gathered on 13 cruises, all totally or partially funded by the BLM. Field samples utilized by L.J. Doyle for the study of sediments and sedimentary processes on the slope were supplied by George Keller, AOML-NOAA, for use by this study. These piston cores were collected from the NOAA Platform RESEARCHER in 1976.

A track chart for the R/V COLUMBUS ISELIN cruise CI 7-78-3, the principal USGS-BLM geophysical cruise in the southeastern Atlantic and for the geophysical cruises reported for FY-77 (Popenoe, 1980a, b) is shown in figure 1. Sample location of vibracores and hydraulically damped gravity cores obtained for ^{210}Pb analyses is shown in figure 2, and location of tracklines used in the study of reefs and hard grounds is shown in figure 3.

GEOLOGIC AND ENVIRONMENTAL SETTING

The southeastern Atlantic OCS consists of two major bathymetric areas (fig. 4); a shallow, flat-bottomed inner shelf (Florida-Hatteras Shelf) where water depths are less than 100 metres (m) and an intermediate depth plateau (Blake Plateau) where depths range from 350 to 1,000 m. A gently sloping transition zone, the Florida-Hatteras Slope, connects the shelf to the plateau, a steeply dipping slope called the Blake Escarpment south of the Blake Spur and called the continental slope north of the Blake Spur, connects the Blake Plateau to the deep ocean floor. The lease areas of Sale 43 lie in the Georgia Bight on the Florida-Hatteras Shelf. This area is within the offshore extension of

Table 3. Summary of cruises conducted in support of the USGS-BLM Environmental Program, FY-78.

Cruise I.D.	Dates	Purpose	Number	Navigation	Chief scientist
R/V FAY 005	31 Oct - 7 Nov 1975	hydraulically damped gravity core	21	Loran-C	H.J. Knebel
		vibracore	21		
R/V FAY 026	16 Oct - 25 Oct 1976	vibracore	20	Int. Nav. System	O.H. Pilkey
		hydraulically damped gravity core	15		
R/V PIERCE	15 Nov - 25 Nov 1977	seston samples	38	Loran-C	L.J. Doyle
R/V EASTWARD E-2E-78	2 Apr - 13 Apr 1978	rock dredge	12	Loran-C	M.W. Ayers
		piston core	42		
		box dredge	26		
		12-kHz profiles	300 km		
		5 in^3 air-gun profiles	300 km		
R/V OCEANUS	2 Feb - 6 Feb 1978	tripod deployment	2	Loran-C	Bradford Butman
R/V COLUMBUS ISELIN	10 Apr - 15 Apr 1978	tripod deployment	1	Loran-C	Bradford Butman
		tripod recovery	2		
Tug WHITEFOOT	13 Jul - 14 Jul 1978	tripod deployment	2	Loran-C	W.J. Strahle
		tripod recovery	1		
R/V BLUEFIN	26 Jun - 30 Jun 1978	3.5-kHz tuned transducer	2,163 km	Loran-C	V.J. Henry, Jr.
	24 Jul - 4 Aug 1978	Uniboom	2,228 km		
	14 Aug - 25 Aug 1978	side-scan sonar	2,255 km		
	11 Sep - 22 Sep 1978	underwater-towed TV	550 km		
R/V STATE ARROW	15 Aug - 19 Aug 1978	sub dives	22	Loran-C	M.M. Ball
Submersible "DIAPHUS"		surface salinity samples	44		
		XBT's	38		
R/V COLUMBUS ISELIN CI 7-78-3	29 Sep - 19 Oct 1978	seismic-reflection 40-in air gun (2)	3,570 km	Int. Nav. System	Peter Popenoe
		minisparker	3,487 km		
		3.5-kHz tuned transducer	3,565 km		

Figure 1. Track chart showing the location of traverses on which high-resolution seismic-refleciton data were gathered in FY-77 and FY-78. Solid lines show traverses on which data were collected in FY-77 and analyses reported in Popenoe (1980a, b). Dashed lines show traverses collected from the R/V COLUMBUS ISELIN cruise, 29 September to 19 October 1978, and the analyses of these data are reported herein. The small block of traverses shown with solid lines on the northern Blake Plateau southwest of drill hole ASP 5 was collected on the R/V FAY 025 cruise in FY-77 as part of a resource analyses effort. The hazards analyses of these data are also reported herein.

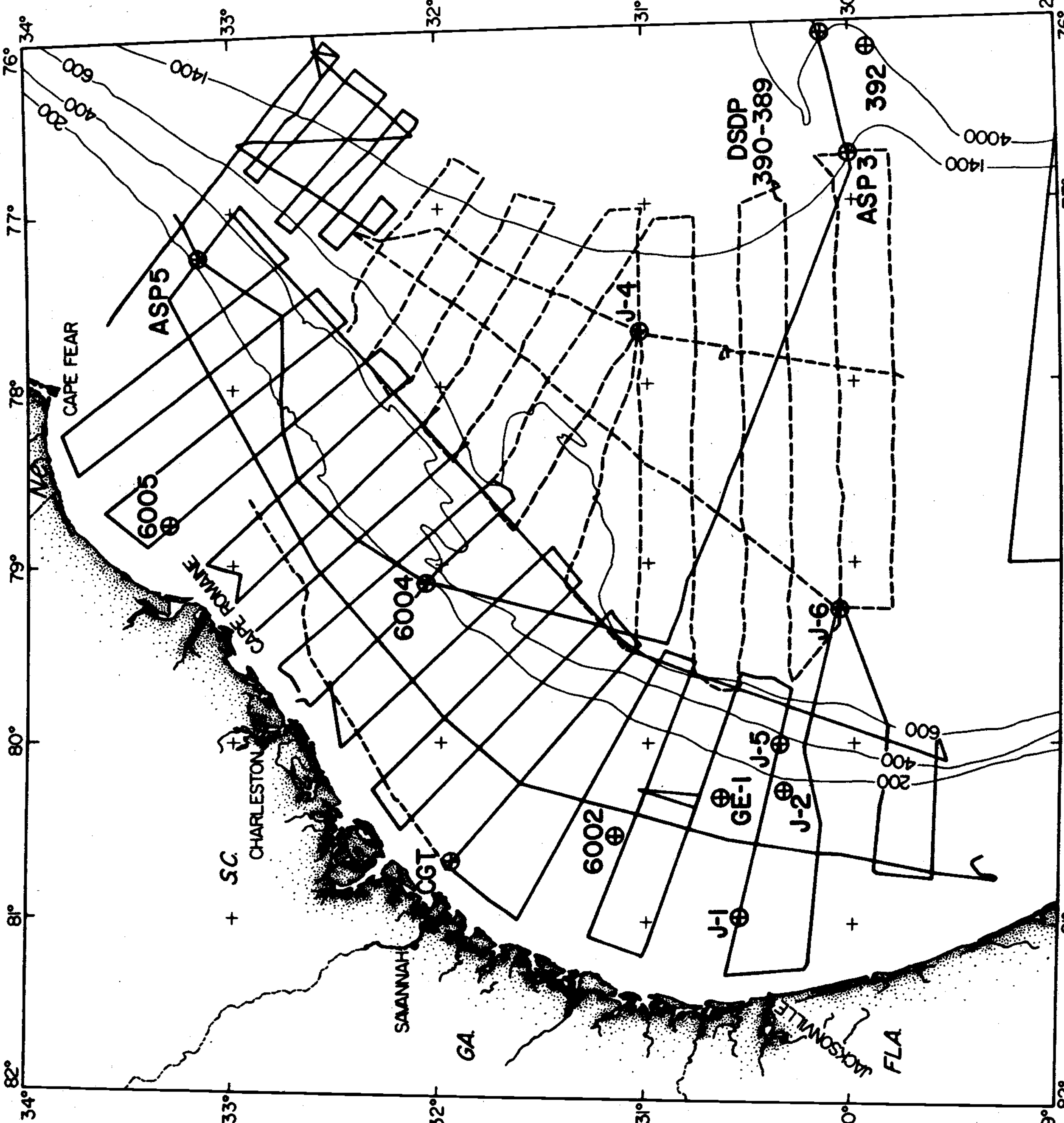

CAPE FEAR
ASP5
6005
CAPE ROMAINE
6004
CHARLESTON
SC
CGT
6002
GA
JACKSONVILLE
FLA
J-1
GE-1
J-2
J-5
J-6
J-4
ASP3
DSDP
390-389
392
200
400
600
1400
4000
34°
33°
32°
31°
30°
29°
82°
81°
80°
79°
78°
77°
76°

Figure 1

Figure 2. Locations of hydraulically damped gravity cores, vibracores, and piston cores analyzed for their ^{210}Pb profiles.

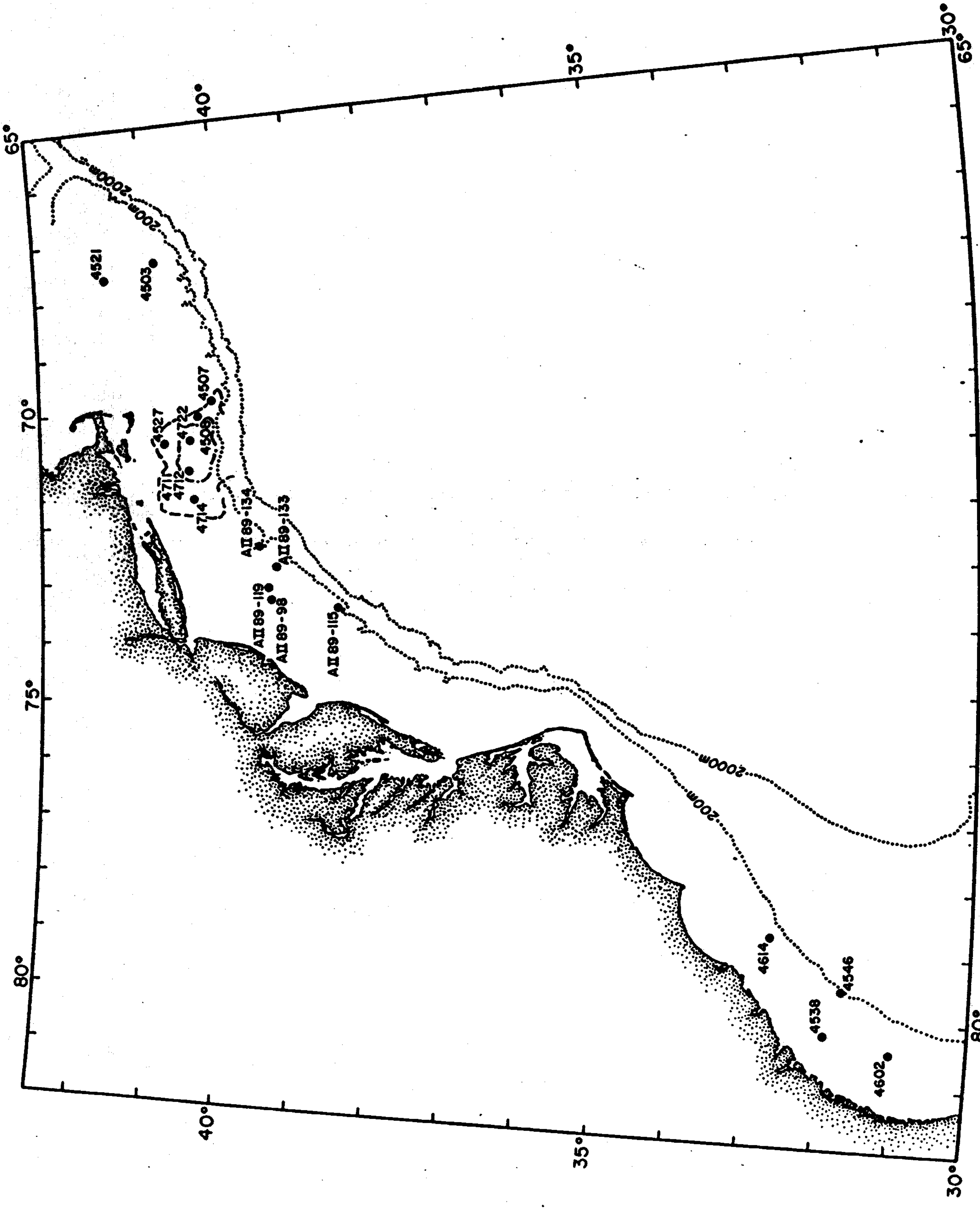

65°
40°
35°
30°
70°
75°
80°
200m
2000m
4521
4503
4507
4527
4722
4509
4711
4712
4714
AII 89-134
AII 89-133
AII 89-119
AII 89-98
AII 89-115
4614
4546
4538
4602

Figure 2

Figure 3. Location of tracklines on which data were collected by the University of Georgia July 1978 to May 1979 for studies of reefs and hard grounds, bottom morphology, and geologic hazards.

Figure 3

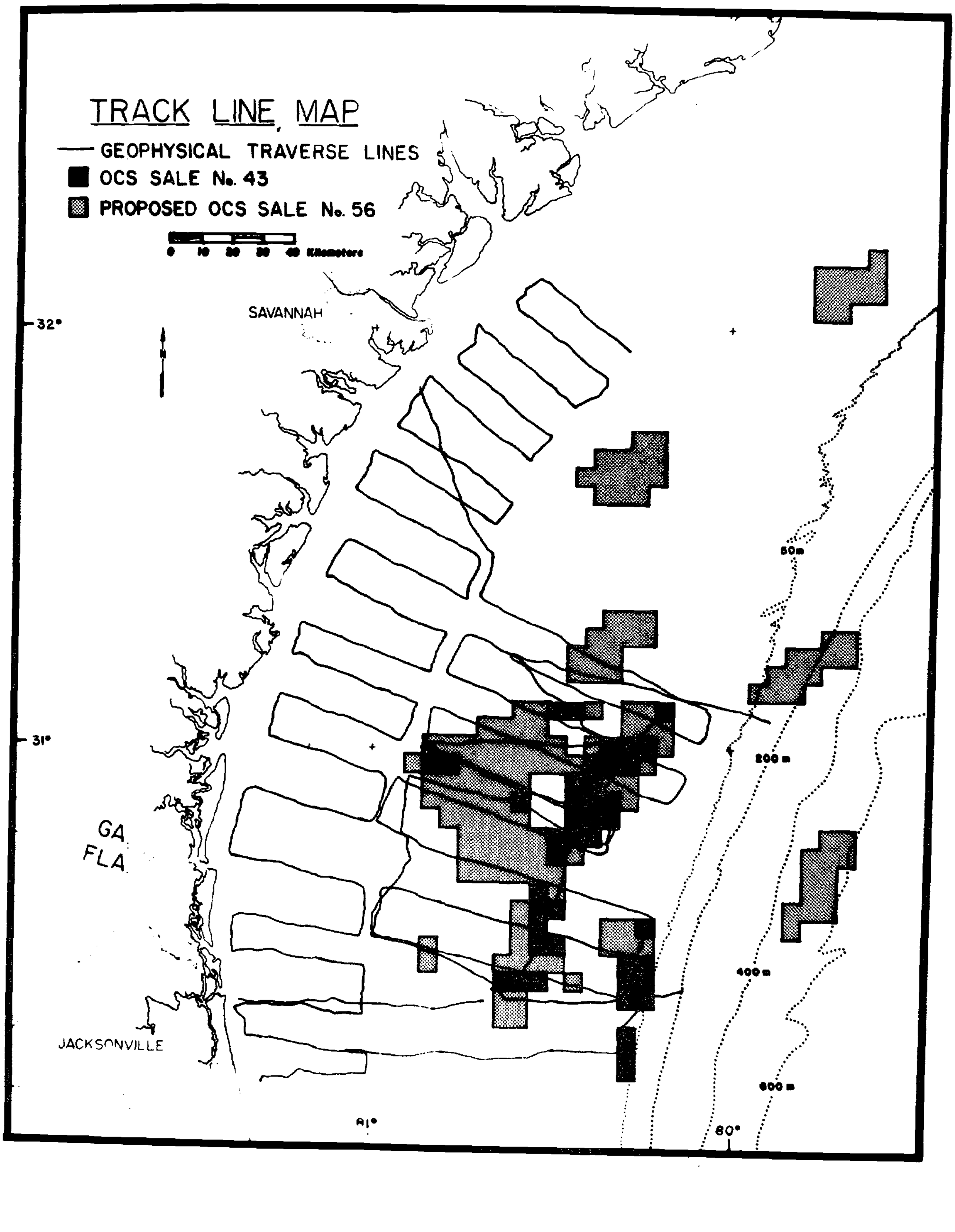
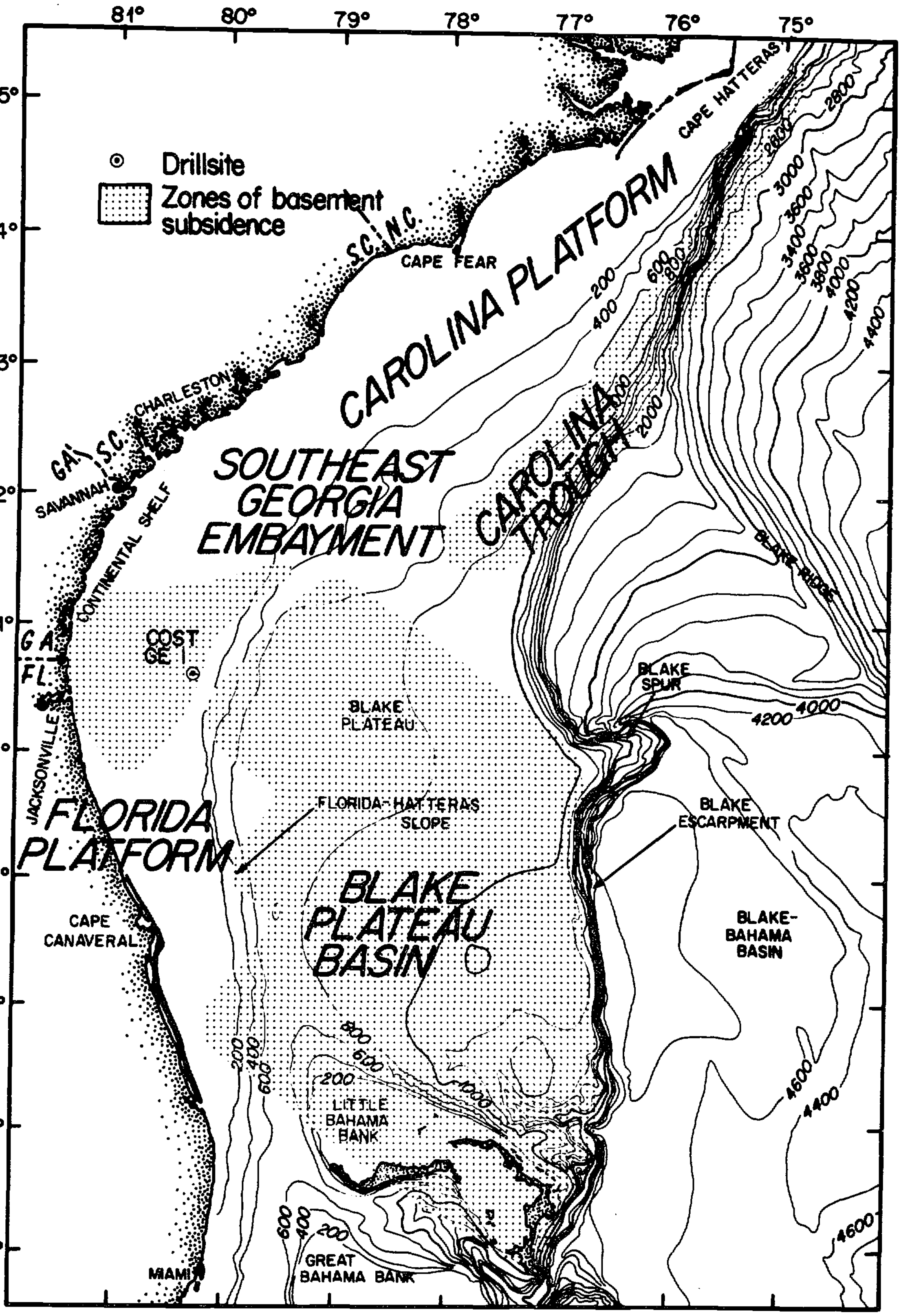

TRACK LINE MAP
GEOPHYSICAL TRAVERSE LINES
OCS SALE No. 43
PROPOSED OCS SALE No. 56
0 10 20 30 40 Kilometers
SAVANNAH
32°
31°
GA
FLA
JACKSONVILLE
50m
200 m
400 m
600 m
81°
80°

Figure 4. Index map showing gross physiography of the southeastern shelf and Blake Plateau and the location of the basin and platform areas.


81°
80°
79°
78°
77°
76°
75°
35°
34°
33°
32°
31°
30°
29°
28°
27°
26°
Drillsite
Zones of basement subsidence
CAPE HATTERAS
S.C. N.C.
CAPE FEAR
CAROLINA PLATFORM
CHARLESTON
GA. S.C.
SAVANNAH
CONTINENTAL SHELF
SOUTHEAST GEORGIA EMBAYMENT
CAROLINA TROUGH
BLAKE RIDGE
GA.
FL.
COST GE 1
BLAKE PLATEAU
BLAKE SPUR
JACKSONVILLE
FLORIDA PLATFORM
FLORIDA-HATTERAS SLOPE
BLAKE ESCARPMENT
BLAKE PLATEAU BASIN
BLAKE-BAHAMA BASIN
CAPE CANAVERAL
LITTLE BAHAMA BANK
GREAT BAHAMA BANK
MIAMI
200
400
600
800
1000
2000
2800
3000
3400
3600
3800
4000
4200
4400
4600

the southeast Georgia Embayment, a seaward opening basin that extends into the coast between the Carolina Platform off North Carolina and the Florida Platform underlying northern Florida (fig. 4)(Klitgord and Behrendt, 1979). The Florida-Hatteras Shelf is formed by a thick wedge of Tertiary sediments which have prograded out to the Gulf Stream, but have been checked in further advance by the strong currents of the Gulf Stream (Paull and Dillon, 1980).

The Blake Plateau, part of the area being offered in Lease Sale 56, lies beneath and east of the Gulf Stream. During the Tertiary Period, sediment accumulation on the plateau has not kept pace with subsidence because the Gulf Stream acted as a barrier to sediment transport from land. The plateau is underlain chiefly by sediments older than Paleocene, and has only a thin section of later Tertiary sediment, chiefly pelagic muds rained down from biologic production in the overlying waters.

Thicknesses of Cretaceous, Tertiary, and Quaternary sediments within the southeast Georgia Embayment aggregate more than 3.4 km. The Blake Plateau is underlain by two deep sedimentary basins, the Blake Plateau Basin and the Carolina Trough (Dillon and others, 1979a and b; Klitgord and Behrendt, 1979; Folger and others, 1980). These deep basins (stippled on fig. 4) which contain 10 to 14 km of sediment chiefly of Jurassic to Paleocene age have no physiographic expression. Because of the greater thickness and greater age of the marine sediments in the Blake Plateau Basin and Carolina Trough, they appear to offer a greater petroleum potential than the sediments of the southeast Georgia Embayment. Drilling in these basins will present more technical and environmental problems, however, both because of greater water depths and strong currents.

The surface of the Florida-Hatteras Shelf is almost entirely covered by a thin layer of sand, generally less than 5 m in thickness, which contains both a component of pre-Holocene, residual quartz sand derived from the last sea-level transgression (Hollister, 1973) and a component of modern calcareous sand (Pilkey and others, 1980). Texturally, these sands are primarily in the 2 to .250 mm range (-1 to 2 Ø); they are generally finer near the coast and on the slope than in the mid-to-outer shelf area (Milliman, 1972; Hollister, 1973; Pilkey and others, 1980). Shelf sands are generally well sorted and reworked by epifauna and currents so that little fine-grained material is available for resuspension. Very little new material is being added to the shelf sediment cover by the river outflow (Doyle and others, 1980; Pilkey and others, 1980). Most suspended material that is not trapped in estuaries bypasses the shelf to be deposited on the slope or swept away by the Gulf Stream or its counter current, ultimately to be deposited on the continental rise.

In some places the thin sand cover of the shelf is absent and a harder, more indurated substrate of cemented sand is exposed. These scattered areas of hard bottom range from relatively smooth outcrop to rough bottoms with relief of up to 15 m. The exposed or nearly exposed hard bottoms generally are covered by a variety of sessile invertebrates; thus hard-bottom areas are areas of biologic production because the attaching organisms and the rough bottom offer both shelter and forage for fish, crustacea, and other bottom-dwelling life. Live-bottom areas are productive recreational and commercial fishing grounds. Where the bottom has more than several metres of relief and is broken, live-bottom areas are called reefs. The most prominent reefs occur near the top of the slope where they are known as the shelf-edge ridge or reef system. Few such areas have been studied in detail; the most important studies are reported by Macintyre (1970), Macintyre and Milliman (1970), Hunt (1974), Continental Shelf Associates, Inc. (1979), and Henry and Giles (1980).

The bottom of the northern Blake Plateau is capped by lag phosphorite gravels and by manganese nodules precipitated from the seawater (Stetson and others, 1969; Macintyre and Milliman, 1970; Manheim and others, in press). The bottom on the western and northern Blake Plateau is characterized by a series of deep elongate and flat-bottomed erosional depressions (Pratt and Heezen, 1964; Uchupi, 1967; Stetson and others, 1969) particularly on the Charleston Bump, the prominent bathymetric high on the northern Blake Plateau, where rocks as old as Cretaceous are exposed at the surface (Paull and others, 1980; Paull and Dillon, 1980). This erosion is exclusively scour by the Gulf Stream and other currents. Bottom roughness beneath the Gulf Stream is enhanced by large conical and elongate banks formed by deepwater corals (Stetson and others, 1962; Ayers and Pilkey, chapter 5, this report). The surface of the southern Blake Plateau is generally smooth, capped by a thin layer of foraminiferal ooze, limestone, and calcarenitic sand.

The shallow subbottom stratigraphy of the shelf, slope, and Blake Plateau has been studied principally by means of seismic refraction and reflection, and by shallow core sampling. The principal early studies (Ewing and others, 1966; Emery and Zarudski, 1967; Uchupi, 1967 and 1970) correlated subsurface offshore units with Coastal Plain stratigraphy, however, the two most comprehensive later studies accomplished under BLM sponsorship (Paull and Dillon, 1980; Pinet and others, chapter 7, this report), correlated seismic intervals and horizons to stratigraphic units determined in offshore wells (McCollum and Herrick, 1964; Bunce and others, 1965; JOIDES, 1965; Hathaway and others, 1976; Schlee, 1977; Poag, 1978; Hathaway and others, 1979). These studies also made the first attempts at seismic stratigraphy based on detailed networks of traverses. In seismic stratigraphic studies seismic sequences, or groups of relatively concordant reflections which are bounded by seismic discontinuities, are mapped around the seismic network. The geometry of reflections and reflection character are interpreted as to the original depositional environment. In many cases the interpreted sequences can be dated and the depositional environment verified with faunal information from core data.

The deeper stratigraphy of the shelf, slope, and Blake Plateau has been studied by interpretation of common-depth-point (CDP) seismic profiles. The most recent of these studies include those of Grow and Markyl (1977), Dillon and Paull (1978), Buffler and others (1979), Dillon and others (1979a and b), and Folger and others (1980). The deepest well drilled into southeastern shelf sediments (COST GE-1) was drilled in the southeast Georgia Embayment to basement in 1977 (Scholle, 1977).

SIGNIFICANT FINDINGS AND CONCLUSIONS

OF THE USGS - BLM

ENVIRONMENTAL GEOLOGIC STUDIES

FY-1978

Components and pathways of seston flux of the Georgia Embayment

L.J. Doyle, P.R. Betzer, Z. Clayton and M.A. Peacock

(Chapter 2)

Sampling of suspended sediments (seston) was carried out in a grid of 29 stations on five transects across the Florida-Hatteras Shelf and slope between Cape Canaveral, Florida and Cape Fear, North Carolina. Water samples were selected from samples collected and analyzed for suspended sediments under the BLM program of FY-77 (Doyle and others, 1980). Stations occupied and vessels used were those of Texas Instruments, Inc. during their physical, biological, and chemical sampling cruises. Shallow stations were sampled near top and bottom and deeper stations were sampled near top, middle, and near-bottom during cruises in spring, summer, fall, and winter. This project was mainly a characterization study to establish trace-metal levels of seston as a check in evaluating future pollution levels. Seasonal seston samples were analyzed for the weak acid soluble Cd, Cu, Fe, Pb, and amorphous silica and refractory Al, Cd, Cu, Fe, Pb, and Si.

Results show that highest concentrations of suspended load and thus of trace metals occur nearshore in the winter, no doubt due to both a relatively high runoff of turbid river water and storm resuspended material. Suspended load values in summer and fall are also quite high, but the relative concentrations of trace metals at these seasons indicate that high load values are generally related to biologic productivity, except nearshore. Lead showed the highest values near Cape Fear suggesting a possible source in Pamlico Sound. A seaward decrease of aluminum silicates, amorphous silica, and weak acid soluble cadmium, copper, iron, lead, and refractory iron is typical throughout the year. These trace metals in suspended material evidently are contributed by outflow from rivers and estuaries and by resuspended bottom sediments in nearshore high energy zones.

^{210}Pb in sediment cores from the Atlantic Continental Shelf: Estimates of rates of sediment mixing

M.H. Bothner and P.P. Johnson

(Chapter 3)

Lead-210 is a naturally occurring short-lived isotope with a half-life of 22.3 years. The isotope is rained down from the atmospheric decay of radon-222 and is deposited on the surface layer of shelf sediments where it is mixed into the sediments by both biological processes and by physical processes of erosion and deposition. By examining the mixing rate of ^{210}Pb and the depth of biological mixing in marine sediments, an estimate can be made of the biological mixing coefficient. Knowledge of the biological mixing coefficient and of the depth of mixing will help us to predict the fate of contaminants added to the continental shelf such as dredge spoils, drilling muds, and other pollutants. From ^{210}Pb studies we can also gain knowledge of which areas of the shelf are undergoing erosion or deposition at the present time.

Four sediment cores were collected on the southeastern shelf with an apparatus designed to not disturb the surficial layer of sediments. These cores, along with 14 cores taken from the north and mid-Atlantic shelves were analyzed for ^{210}Pb distribution.

Results show that shelf sediments are typically mixed to a depth of 20 to 28 cm. The upper 9 cm are generally relatively rapidly mixed by both organisms and currents; the upper 5 cm are generally mixed in about

5 years. Below 10 cm a slower rate of mixing chiefly due to biological processes is generally apparent.

Cores from the southeast Georgia Embayment show a general decrease of ^{210}Pb with depth but the decrease does not follow the theoretical concentration curve, suggesting deep and rapid mixing by currents. These results suggest that pollutants would be similarly mixed. The only site found to be actively accumulating sediments in the study area, thus a modern sink for fine-grained sediments and for pollutants, was an area of mud south of Martha's Vineyard. The source of these sediments is probably the Georges Bank, an area found to be undergoing active erosion.

Sediments and sedimentary processes as interpreted from piston cores and grab samples from the continental slope of the southeastern United States

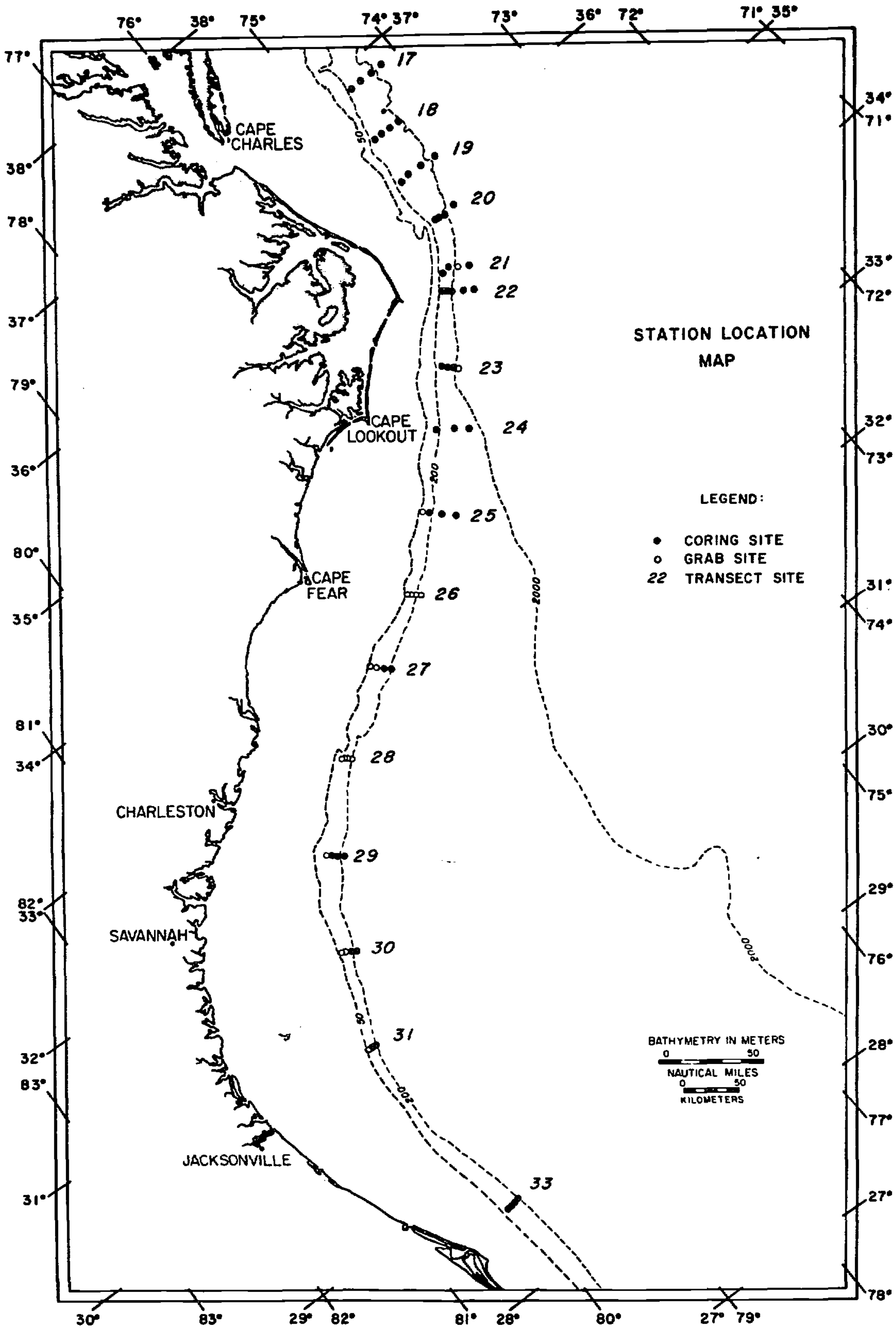
L.J. Doyle, F.M. Wall, and P. Schroeder

(Chapter 4)

Forty-four piston cores up to 6 m in length from 15 transects across the Florida-Hatteras and continental slope, and 17 grab samples, all from the continental slope or rise, were studied (fig. 5). Samples were analyzed for texture, percent $CaCO_3$, total organic carbon, and clay mineralogy. This study was made to determine compositional characteristics of slope sediments; the depositional processes that affect slope sediment composition; the role and relationship of the adjacent continental shelf in furnishing sediment to the slope; and the pollution sink potential of the slope sediments.

Texturally, sediments of the Florida-Hatteras Slope range in size from sand to clay, most samples being in the fine to very fine sand

Figure 5. Location map of piston core and grab sample sites studied for compositional characteristics of slope sediments.


STATION LOCATION
MAP
LEGEND:
CORING SITE
GRAB SITE
22 TRANSECT SITE
BATHYMETRY IN METERS
NAUTICAL MILES
KILOMETERS
CAPE CHARLES
CAPE LOOKOUT
CAPE FEAR
CHARLESTON
SAVANNAH
JACKSONVILLE
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
33
50
200
2000

range with the finer fraction increasing downslope. Silt and clay are important constituents near the base of the slope. North of Cape Hatteras fine-grain sediments dominate the surface of the upper rise.

Calcium carbonate content of slope sediments is high south of Hatteras, and highest on the Florida Shelf. A transition zone exists approximately between Jacksonville and Cape Hatteras where quartz sand and carbonate sand, consisting chiefly of shell hash and planktonic foraminifera tests, are mixed. North of Hatteras, quartz sand of terrigenous origin is dominant.

The size distribution and the compositions indicate that most slope sediments result from shelf-edge spillover caused by large storms or by Gulf Stream incursions on the shelf. Most sands are not deposited in graded beds but at a few sites samples of graded sediments suggest that turbidity currents may have transported sediment downslope. Some slope sediments show evidence of gas, probably methane.

Slope sediments show clear evidence of bioturbation, a process which probably helps eliminate the fine-grained component. Some resuspended fines swept away by Gulf Stream currents are redeposited through fecal pellet formation, which combined with a rain of planktonic foraminifera tests, form a hemipelagic detrital component downslope. The presence of a volumetrically significant fine fraction, particularly in downslope areas, suggests that pollutants which become involved with the fine-grained component will be deposited with it. The formation and rapid deposition of fecal pellets may serve to accelerate this process.

Piston core and surficial sediment investigations of the Florida-Hatteras Slope and inner Blake Plateau

M.W. Ayers and O.H. Pilkey

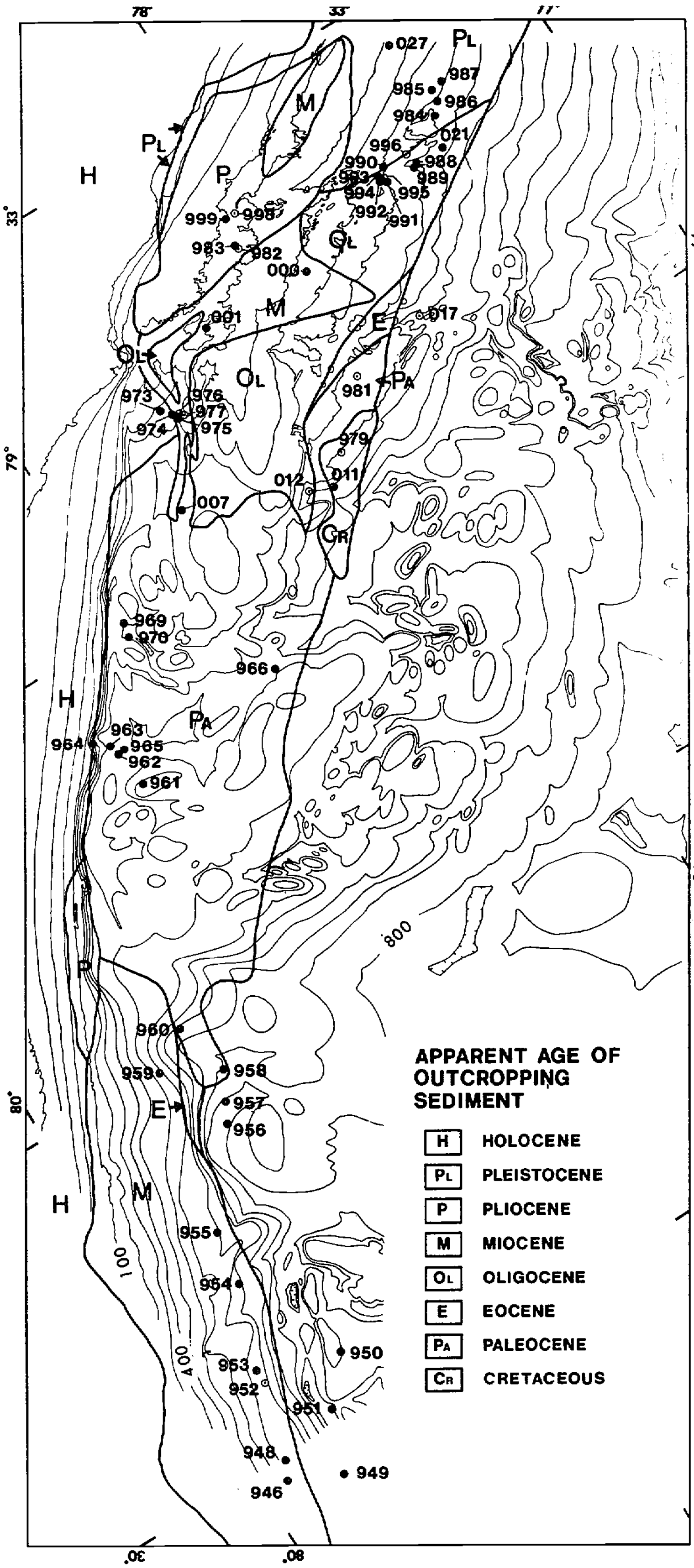
(Chapter 5)

Forty-two piston cores and 200 surficial samples from the Florida-Hatteras Slope and inner Blake Plateau were examined (fig. 6). Sediment composition and texture in these cores indicates that shelf-edge spillover probably resulting from high wave energy during storms and by Gulf Stream incursions on the shelf is the dominant sediment transport process on the slope, although slumping and density current deposition also occur. In contrast, sediments on the inner Blake Plateau are mainly residual from erosion of pre-Holocene units that outcrop or subcrop on the plateau, or are biogenic derived from normal pelagic processes.

Slumping on the Florida-Hatteras Slope is rare and only one large slump mass has been reported (Popenoe, 1980a, b). Seismic-reflection surveying of the slump mass shows that it covers an area of 135 km^2, has a volume of 1.3 x 10^8 m^3 and is located at the base of the slope between the 400 and 500 m isobaths at lat 32°N. and long 79°W. Core data from near the toe of the slump and radiometric ages of sediments recovered beneath the slump suggest a post-Pleistocene age for the feature.

Six species of deepwater corals were recovered from the plateau, however, only two species are of the colonial variety which build coral banks. Radiocarbon dates on corals show that corals have existed on the plateau since at least late Pleistocene time.

Figure 6. Location of rock dredge (circles) and piston core (dots) from the slope and inner Blake Plateau studies for compositional variations and depositional process studies.


APPARENT AGE OF OUTCROPPING SEDIMENT
H HOLOCENE
PL PLEISTOCENE
P PLIOCENE
M MIOCENE
OL OLIGOCENE
E EOCENE
PA PALEOCENE
CR CRETACEOUS
800
100
400

Ocean bottom survey of the Georgia Bight

V.J. Henry, Jr., C.J. McCreery, F.D. Foley, and D.R. Kendall

(Chapter 6)

3.5-kHz tuned transducer, Uniboom[1] seismic-reflection, side-scan sonar, and underwater-towed television surveys were made along dip-line traverses spaced 10 km apart (fig. 3) across the Georgia and northern Florida Shelf to determine the occurrence and distribution of biologically sensitive areas (reefs/live bottoms) and hazardous shallow geological features (channels, faults, scour, etc.). A series of eight maps were prepared depicting: A) texture/bed forms; B) hard bottom/live bottom; C) shallow subsurface geology; and D) biota observed by closed-circuit TV along the traverses.

Surface textural character of bottom sediment was discernible from sonograms. In most instances coarse textures indicate outcrops of hard bottoms often supporting live bottoms. Fine-grained sediments are generally associated with a thin, mobile veneer of sand which makes up much of the surface of the shelf. A variety of mobile bed forms were discernible and mapped. These include ripples, megaripples, reticulated bottom, areas of local scour, or bioturbation.

At least two shallow subsurface reflectors cut by channels and cut-and-fill structures are discernible throughout the area in the shallow subsurface. These erosional surfaces probably reflect subareal exposure of the shelf during low sea-level stands, perhaps in

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[1]Use of brand names in this report is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

mid-Pliocene and mid-Miocene time. Larger channels, up to 40 m in depth, are associated with the deeper reflector, while smaller channels and cut-and-fill structures are associated with the shallower reflector. The deeper channels are discontinuous and probably reflect tidal channels cut during stillstands of sea level. Shallower channels have apparently been erased by the sea-level transgression.

Reefs and hard-ground areas are discontinuously scattered across the shelf. Hard bottoms of moderate relief (up to 2 m), many of which are also live bottoms, are most common between the 15 and 30 m isobaths and in most cases are related to outcrop of a strong subsurface reflector. High-relief hard bottoms (3 to 15 m) occur mainly near the shelf edge between the 30 and 100 m isobaths. Both types of hard bottoms are typified by blocky, irregular rock outcrops with sand filled cracks and joints.

Sesimic stratigraphy of the northern and central Blake Plateau

P.R. Pinet, P. Popenoe, S.M. McCarthy, and M.L. Otter

(Chapter 7)

Over 4,700 km of single-channel air-gun, sparker, and 3.5 kHz seismic-reflection profiles, gathered chiefly on the R/V COLUMBUS ISELIN cruise but supplemented by data from the R/V FAY 17, 18 and 25 cruises, were examined and interpreted for seismic stratigraphic units. Cruise tracks are shown in figure 1. Ages of reflection units are provided by correlation of these units with drill hole core intervals from three well sites on the Blake Plateau and on correlations with seismic sequences mapped by Paull and Dillon (1980) for the Florida-Hatteras Shelf and inner Blake Plateau.

Cretaceous strata are divided into four major units. A basal

Albian sequence of general transparent seismic character indicating marine carbonate deposition underlies both the northern and southern plateau. North of 31°N. three progradational sequences, a Coniacian-Turonian sequence, a Santonian sequence, and a Campanian-Maestrichtian sequence overlie the Albian. Seismic character indicates that these rocks are chiefly clastic and were deposited in shelf and continental slope environments. They dip generally eastward reflecting subsidence of the margin into the Carolina Trough. South of 31°N. the Cretaceous units are chiefly of transparent seismic character and are interpreted as deepwater carbonate facies rocks. These rocks dip generally landward reflecting subsidence along the western Blake Plateau Basin; they rise to the east towards the Blake Escarpment where an Albian-Aptian reef complex forms a prominent subsurface topographic high.

Three thin sequences whose ages are inferred to be Paleocene, Eocene-Oligocene, and post-Oligocene comprise the Cenozoic section. These units are generally deepwater deposits of foraminiferal ooze, limestone, and calcarenitic sand reflecting sediment starvation on the outer Blake Plateau caused by the Gulf Stream barrier to sediment transport from land.

From Paleocene to Recent time the Gulf Stream has been the dominant force in shaping the southeastern margin, controlling the sedimentation patterns and the location of the shelf edge.

Structure contour and isopach or unit thickness maps are constructed for all units. These maps will be useful in predicting aquifer locations, cavernous limestone units, foundation support characteristics, and other environmental parameters for petroleum exploration and production plans.

An assessment of potential geologic hazards of the northern and central Blake Plateau

P.R. Pinet, P. Popenoe, M.L. Otter, and S.M. McCarthy

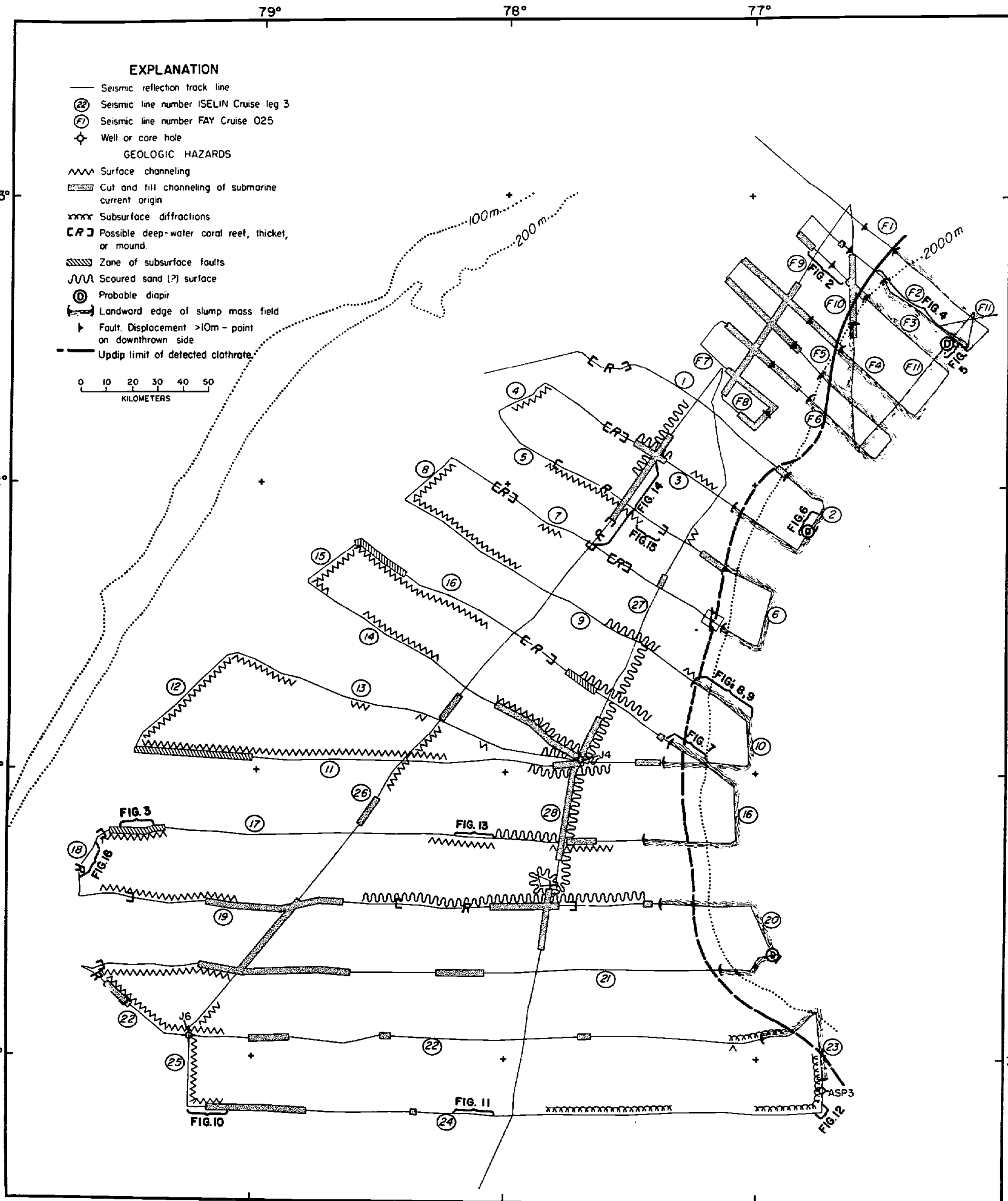
(Chapter 8)

A geologic hazards map of the Blake Plateau (fig. 5) constructed from analyses of seismic-reflection data shows that faults are not common except near the Blake Escarpment where considerable slumping of slope sediments is observed. Cut-and-fill structures, scour channels, steep topography, and deepwater reefs are ubiquitous but pose no insurmountable problems to drilling operations. Four features noted will pose problems in exploration and development of petroleum resources off the Blake Plateau.

The first, and perhaps most difficult problem is presented by the powerful currents of the Gulf Stream which sweep the plateau's surface and have excavated numerous scour depressions and channels in the past. Second, bottom simulating reflectors were noted in water depths of below 800 m, these reflectors probably indicate a frozen gas hydrate layer in the shallow subbottom. Amplitude anomalies of reflectors (bright spots) beneath the frozen layer strongly suggest large pockets of shallow gas which could result in blowouts, fire, and rig loss, if penetrated without proper precautions. Shallow gas trapped beneath the clathrate layer was also noted overlying salt diapirs on the upper rise (fig. 5). This environmental hazard must be considered in exploration plans of these potential petroleum structures. Third, reflector configurations of Paleocene limestone units in the southern part of the survey area suggest massive solution features. Solution features could result in loss of drilling fluid, loss of drill stem, or unstable platform

Figure 7. Geologic hazards map of the central and northern Blake Plateau. Figure locations refer to illustrations in Chapter 8 of Popenoe (1980c).

Figure 7


EXPLANATION
Seismic reflection track line
Seismic line number ISELIN Cruise leg 3
Seismic line number FAY Cruise 025
Well or core hole
GEOLOGIC HAZARDS
Surface channeling
Cut and fill channeling of submarine current origin
Subsurface diffractions
Possible deep-water coral reef, thicket, or mound
Zone of subsurface faults
Scoured sand (?) surface
Probable diapir
Landward edge of slump mass field
Fault. Displacement >10m - point on downthrown side
Updip limit of detected clathrate
0 10 20 30 40 50
KILOMETERS
79°
78°
77°
33°
33°N
32°
31°
30°
100m
200m
2000m
FIG. 2
FIG. 3
FIG. 4
FIG. 5
FIG. 6
FIG. 7
FIG. 8,9
FIG. 10
FIG. 11
FIG. 12
FIG. 13
FIG. 14
FIG. 15
FIG. 16
J4
J6
ASP3

support. Fourth, the great water depths on the outer plateau are at the frontier of exploration and production technology at the present time.

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