REVIEW OF SEISMIC REFLECTION DATA FROM THE NORTH CAROLINA COASTAL PLAIN AND ADJACENT CONTINENTAL SHELF

OPEN-FILE REPORT 90-1

BY

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RALEIGH

1990

State of North Carolina

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INTRODUCTION

This report reviews available seismic-reflection data from North Carolina's continental shelf and adjacent offshore region. Data on file at the North Carolina Geological Survey includes almost 600 miles of multi-channel seismic-reflection profiles from the northeastern Coastal Plain of North Carolina. The stratigraphic interval represented on these seismic lines includes the lower Neogene, Paleogene, Cretaceous, and crystalline basement. Other relevant data sources on file at the North Carolina Geological Survey include geologic reports, well samples, well logs, and synthetic seismograms.

This report also lists sets of seismic data from the North Carolina shelf and offshore area which were collected by agencies of the federal government and various academic institutions. The geographic coverage of these data sets is shown in Appendix 2.

NORTH CAROLINA GEOLOGICAL SURVEY'S SEISMIC REFLECTION DATA

Location

Cities Service Oil and Gas Corporation donated paper copies of 24 lines (597 miles) of multi-channel seismic-reflection data to the North Carolina Geological Survey. These are divided into three subsets by geographic coverage. Key parameters which characterize the seismic lines are listed in Appendix 1. These seismic lines were acquired by the indicated seismic contracting companies for Cities Service Oil and Gas Corporation in 1972.

The largest subset consists of 16 lines (393.3 miles) of 12-fold common depth point stack (CDPS) data recorded to 4 seconds two-way travel time. Geophysical Service, Incorporated (GSI) recorded these lines in state waters of Albemarle and Pamlico Sounds and adjacent waterways (figure 1).

The second subset consists of 6 lines (165.8 miles) of 24-fold CDPS data recorded to 7 seconds two-way travel time. Digicon recorded these lines just offshore from and parallel to the Outer Banks, from Cape Lookout to the Virginia boundary.

The third subset consists of 2 lines (37.9 miles) of 12-fold CDPS data recorded to 3 seconds two-way travel time. Western Geophysical recorded these lines onshore in Dare County, along U. S. 64 and U. S. 264.

Previous Work

Some of the seismic-reflection profiles on file at the North Carolina Geological Survey were discussed in recent reports. Six seismic lines (W-3, W-23, G-2, G-3, G-4, and G-9) were analyzed by Hoffman and others (1985) and Almy (1987). Hoffman and others (1985) reviewed these seismic lines along with data from five synthetic seismograms and eight wells. Distinctive features from the synthetic seismograms were correlated with lithofacies in the wells, and prominent seismic reflectors were characterized.

Seismic-reflection data and well data examined by Hoffman and others (1985) was interpreted further by Almy (1987). Almy also examined logs from 11 additional wells, nine of which also have synthetic seismograms. Based on this information, Almy divided the Cretaceous section into five units and constructed average and interval velocity maps and structure maps. Almy (1987) attributed control of depositional patterns of Cretaceous strata to topography of the crystalline basement and differential compaction of shelf sediments.

Underwood (1988) correlated and mapped the top of crystalline basement and four overlying seismic horizons on the 16 GSI seismic lines. His report includes discussions of reflector character, structure, and depositional setting for these seismic lines (Underwood, 1988). Additionally, Underwood calculated tables of average velocities from sonic logs from four wells, and provided these to the Survey.

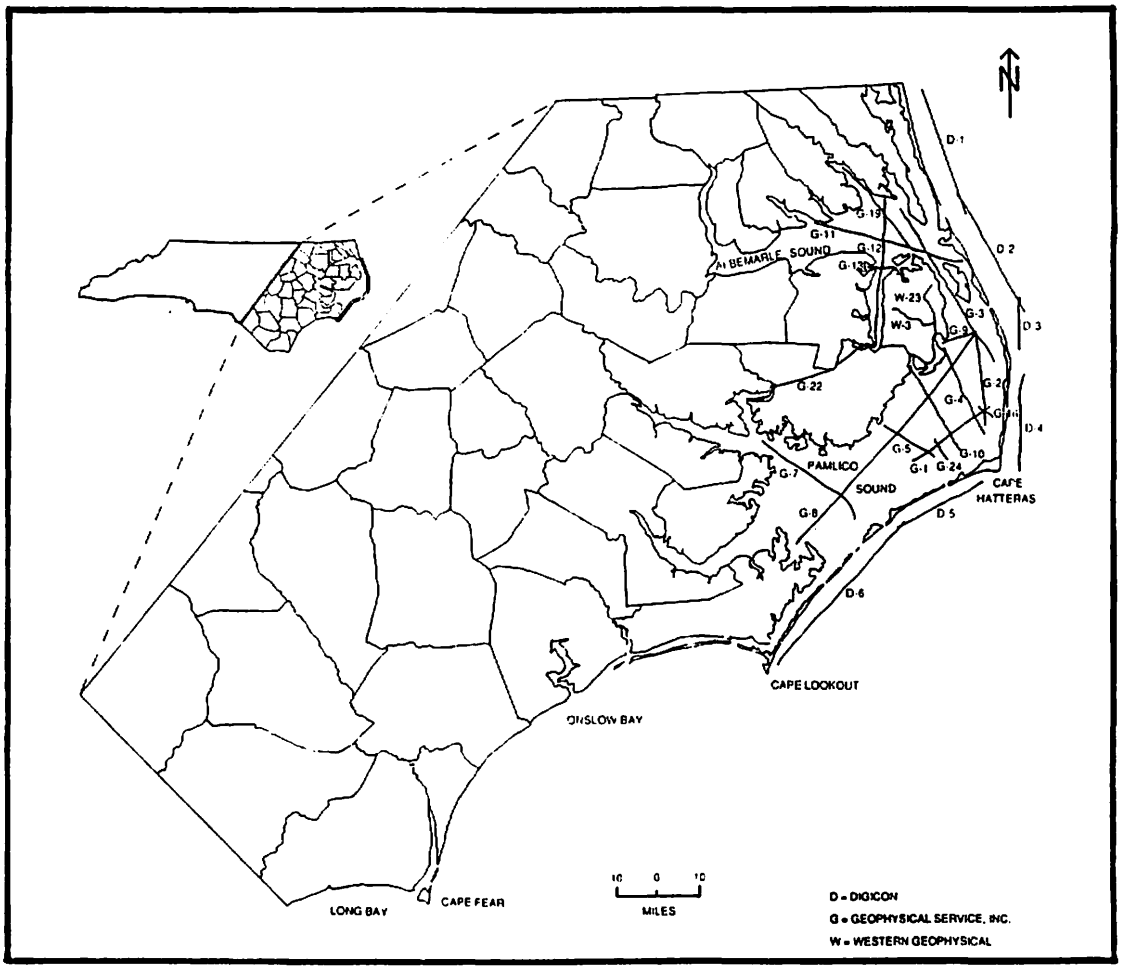

Figure 1. Map of eastern North Carolina showing locations for the multi-channel seismic-reflection profiles on file at the North Carolina Geological Survey.

Zarra (1989) integrated the seismic analysis of Underwood (1988) with paleontologic and well log data, and additional seismic interpretations. Zarra's study defined 26 depositional sequences and 26 sequence boundaries for the Lower Cretaceous to Quaternary subsurface section of the Pamlico and Albemarle Sounds. Sequence stratigraphic relationships were delineated by correlating seismic reflectors, foraminiferal biostratigraphy, and well logs (Zarra, 1989).

Geologic Overview

The Cretaceous and Paleogene stratigraphic section is composed of sedimentary rocks which are represented on the seismic profiles by parallel to subparallel reflectors with variable but generally good continuity (figure 2). The lithologic column on the left side of figure 2 illustrates the lithology of the Mobil #2 well (API # 32055-00004) which is located at the intersection of seismic lines G-1, G-2, and G-16 (see figure 1). Exceptions to the generally even and concordant alignment of reflectors include localized sigmoid clinoforms, channels, and truncation of reflectors by onlap, erosion, and faulting (Almy, 1987; Underwood, 1988; Zarra, 1989). An example of the localized sigmoid clinoforms occurs in the lower part of the Neogene section on figure 2. Popenoe (1985) documented similar features on nearby single channel seismic profiles. Above 0.2 to 0.3 seconds on the CDPS data, reflectors are not coherent. This upper interval encompasses half of the Neogene in the southeastern part of the seismic network, and much of the Paleogene to the west and north.

The seismic horizon correlated to the top of crystalline basement is a prominent feature on the GSI and Western Geophysical seismic profiles (figure 2). On these profiles Underwood (1988) interpreted the top of basement at a trough between two generally continuous, high amplitude reflectors. This horizon ranges from 0.94 seconds at the west end of line G-11 to 1.87 seconds at the east end of line G-16. Basement topography is generally even and is offset by numerous faults with little vertical displacement (Almy, 1987; Underwood, 1988). Erosional topography with relief up to 0.1 second occurs on the west half of lines G-11 and G-19. Both Almy (1987) and Underwood (1988) interpreted minimal faulting extending into the overlying Lower Cretaceous strata.

With few exceptions, the overall quality of the seismic profiles is good for 18-year-old data. Some of the profiles contain restricted intervals of vertically aligned distortions which may be attributed to acoustic disturbances. Three of the profiles (G-3, G-12, and G-22) contain gaps equivalent to 32 to 145 shotpoints. Also, the western portions of lines G-7 and G-22 contain distorted areas.

Related Data

Information from wells constitutes an important auxiliary data set for seismic studies in the Coastal Plain of North Carolina. Descriptions of holdings and procedures for obtaining information from the North Carolina Geological Survey's repository of core, cuttings, and well logs was described by Hoffman and Nickerson (1988). Geographic locations of wells are given by Nickerson and Hoffman (1988).

The North Carolina Geological Survey maintains two computer files, called Welldata and Oiltest, for the State's Coastal Plain. The Welldata file lists key parameters for 555 stratigraphic test wells and water wells. A majority of these wells are between 50 and 500 feet deep, with a few ranging up to 1,600 feet deep. The Oiltest file lists key parameters for 120 petroleum exploration wells from the Coastal Plain plus 5 wells from the Sanford Triassic Basin. The Coastal Plain wells are between 168 and 10,044 feet deep, with a majority between 1,000 and 5,000 feet deep. Samples and/or well logs are available for all of the wells in the Welldata file and for more than 90 percent of the wells in the Oiltest file.

Nine of the State's oil and gas test wells are located on the North Carolina Geological Survey's seismic network; five of these are onshore in Dare County, three are in Pamlico Sound, and one is in Albemarle Sound. Synthetic seismograms are available for eight of these wells. Seven petroleum test wells are located within five miles of the seismic network. Synthetic seismograms are available for four of these wells. Synthetic seismograms are also available for six

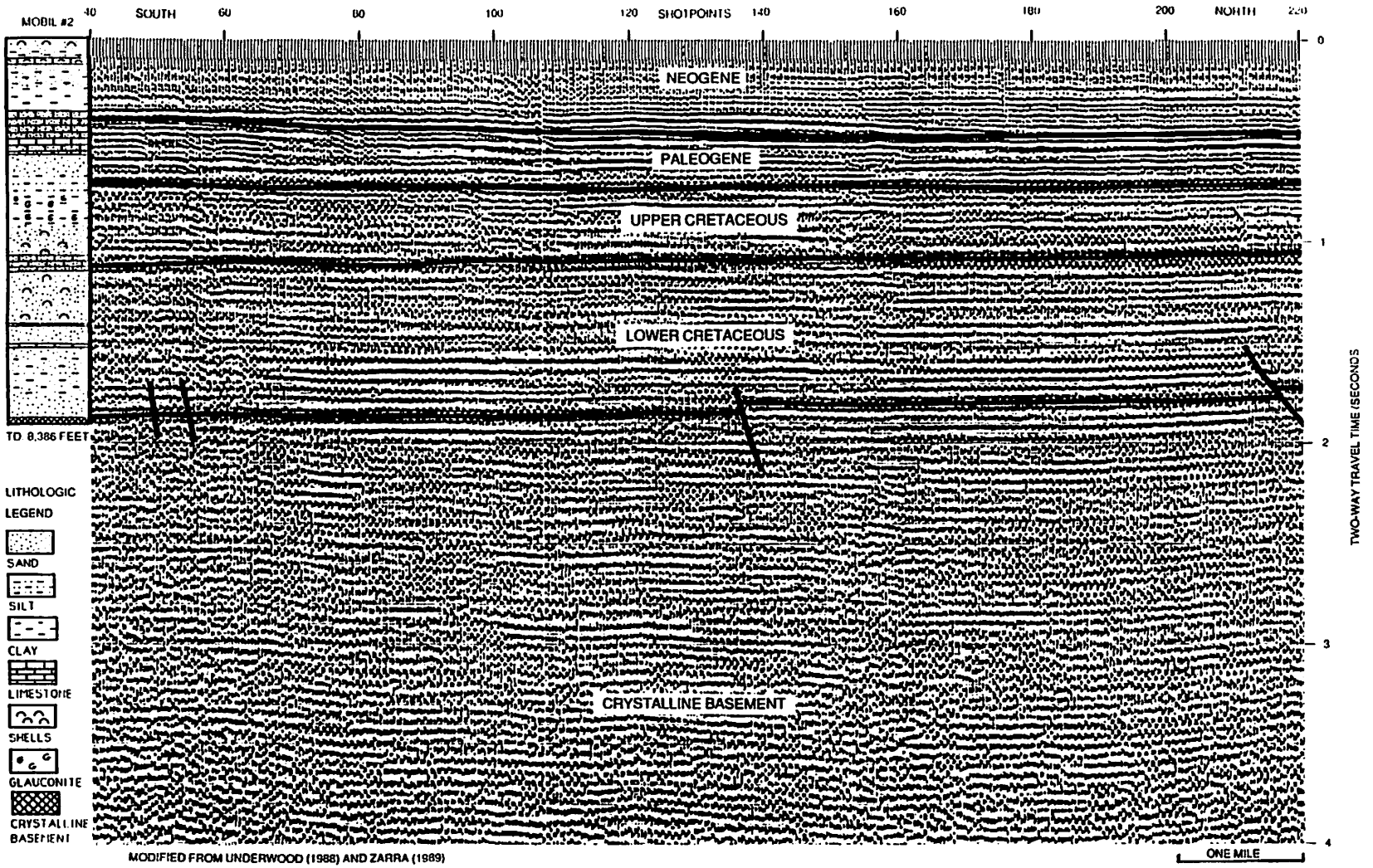

Figure 2. A segment of Seismic line G-2 north of its intersection with seismic lines G-1 and G-16 and the Mobil #2 well. Major seismic packages, and a simplified lithologic log for the Mobil #2 well are shown.

additional Coastal Plain wells. These synthetic seismograms are discussed by Hoffman and others (1985) and Almy (1987).

OTHER LOCAL SEISMIC-REFLECTION DATA

An abundance of multi-channel and single-channel seismic-reflection data has been collected from North Carolina's continental shelf and adjacent offshore area by the the federal government, various academic institutions, and the petroleum industry. Seismic data acquired by the petroleum industry is, almost without exception, proprietary. However, much of the local seismic-reflection data collected by the federal government and academic institutions are available at one or more of the data repositories listed below. Usually the U. S. Geological Survey's seismic data is released for sale via the National Oceanic and Atmospheric Administration, National Geophysical Data Center (NOAA/NGDC) at Boulder. Available local seismic-reflection data is briefly reviewed below; tracklines or locations for these data are shown in Appendix 2. Seismic lines cited in this section are not on file at the North Carolina Geological Survey.

National Oceanic and Atmospheric Administration
National Geophysical Data Center
Marine Geology & Geophysics Division (E/GC3)
325 Broadway
Boulder, Colorado 80303

U. S. Geological Survey
Data Library
Branch of Atlantic Marine Geology
Quissett Campus
Woods Hole, Massachusetts 02543

Department of Marine, Earth, and Atmospheric Sciences
Seismic Data Library
North Carolina State University
P. O. Box 8208
Raleigh, North Carolina 27695

The U. S. Geological Survey has collected several sets of multi-channel seismic-reflection data offshore from North Carolina. Tracklines of these offshore profiles are shown in Appendix 2a. The cross-hatched tracklines represent USGS/IPOD (International Program of Ocean Drilling) seismic lines. The original profiles for tracklines shown in Appendix 2a are available for examination at the USGS Data Library at Woods Hole. Copies of these data are available from NOAA/NGDC at Boulder.

The NOAA/NGDC has records of additional seismic-reflection data collected from North Carolina's shelf and offshore region by several academic institutions and federal government agencies. Appendix 2b shows tracklines of multi-channel seismic data from Lamont-Doherty Geological Observatory, Woods Hole Oceanographic Institute, and the Minerals Management Service. Appendix 2c shows tracklines of multi-channel seismic data from Scripps Institution of Oceanography, the National Oceanic and Atmospheric Administration, the U. S. Navy, and Texas A & M University. Copies of these data are also available from NOAA/NGDC at Boulder.

The U. S. Geological Survey has made an extensive collection of single-channel seismic-reflection data from the North Carolina continental shelf and offshore waters. Tracklines shown in Appendix 2d are representative of the single-channel seismic coverage in this area. Approximately 2,000 miles of the USGS single-channel data are located shoreward of the 200 meter isobath, with a similar amount of data in deeper water (Popenoe, 1985, figure 4-3). Popenoe (1985) analyzed these and other data for his interpretation of Cenozoic depositional history of the North Carolina shelf. The original single-channel seismic data is available for examination at the USGS Data Library at Woods Hole, and copies are available from the NOAA/NGDC at Boulder. Additionally, copies of some of these data are on file at the North Carolina State University, Department of Marine, Earth, and Atmospheric Sciences (NCSU/MEAS) Seismic Data Library.

An additional set of single-channel seismic data from the Minerals Management Service is shown on Appendix 2a. The stippled areas represent tight grids of high-resolution data recorded at selected Outer Continental Shelf lease sale blocks. Copies of these data are available from NOAA/NGDC.

Another set of offshore single-channel seismic-reflection profiles is from Cape Lookout to the South Carolina boundary. Approximately 8,000 miles of seismic data from several sources are centered in Onslow Bay and Long Bay, between the coast and the 50 meter isobath (Hine and Riggs, 1986). Miocene strata in this area have been the subject of intensive investigation (Snyder and others, 1988). Copies of most of the single-channel seismic data from the North Carolina continental shelf reside in the seismic data library of the Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh (Stephen W. Snyder, oral communication, 1989).

UTILITY OF DATA

Using selected seismic profiles on file at the North Carolina Geological Survey, Almy (1987) divided the Cretaceous section into five seismic packages. Underwood (1988) divided the Cretaceous and Tertiary section into five seismic packages with different boundaries than those interpreted by Almy (1987). Zarra (1989) refined Underwood's seismic framework and correlated reflectors to foraminiferal biostratigraphic horizons for the Upper Cretaceous and Paleogene section. While these interpretations demonstrate the utility of this data set, work done to date is not comprehensive. The Digicon seismic lines have not been interpreted. For the remainder of the seismic lines, stratigraphic interpretations of the sedimentary section are preliminary and provide a framework for future studies.

Almy (1987) and Underwood (1988) made preliminary structural interpretations for the top of crystalline basement to gain a better understanding of the overlying sedimentary section. However, little work has been done with most of the basement section, and it is not clear what level of interpretation the seismic-reflection data below the top of crystalline basement will support.

No attempt has been made to tie the North Carolina Geological Survey's seismic-reflection data with adjacent sets of single- or multi-channel seismic-reflection data. However, renewed interest in local offshore petroleum exploration underscores the need for a comprehensive interpretation integrating the Survey's nearshore seismic-reflection data with other sets of multi-channel seismic-reflection data located offshore from North Carolina. In addition, a combined interpretation of the Survey's seismic-reflection data and adjacent single-channel seismic-reflection data sets could be used to resolve fine details of the Tertiary depositional systems. Detailed stratigraphic interpretations of this type may also have environmental applications.

AVAILABILITY OF NORTH CAROLINA GEOLOGICAL SURVEY'S SEISMIC DATA

The seismic-reflection data on file at the North Carolina Geological Survey is available for examination by appointment, and copies of individual seismic lines may be purchased. Limited space is usually available in our sample repository for inspection of seismic lines. For additional information, contact:

North Carolina Geological Survey
Coastal Plain Office
4100 Reedy Creek Road
Raleigh, NC 27607 Telephone: (919) 733-7353

ACKNOWLEDGEMENTS

The North Carolina Geological Survey acknowledges the donation of 597 miles of multi-channel seismic-reflection profiles from Cities Service Oil Company. The author is grateful to Peter Popenoe, Stephen W. Snyder, and the staff of the National Geophysical Data Center for providing information on local seismic-reflection data. Review comments from Edward R. Burt, Charles W. Hoffman, Carl E. Merschat, and Jeffrey C. Reid significantly improved the organization and clarity of this report.

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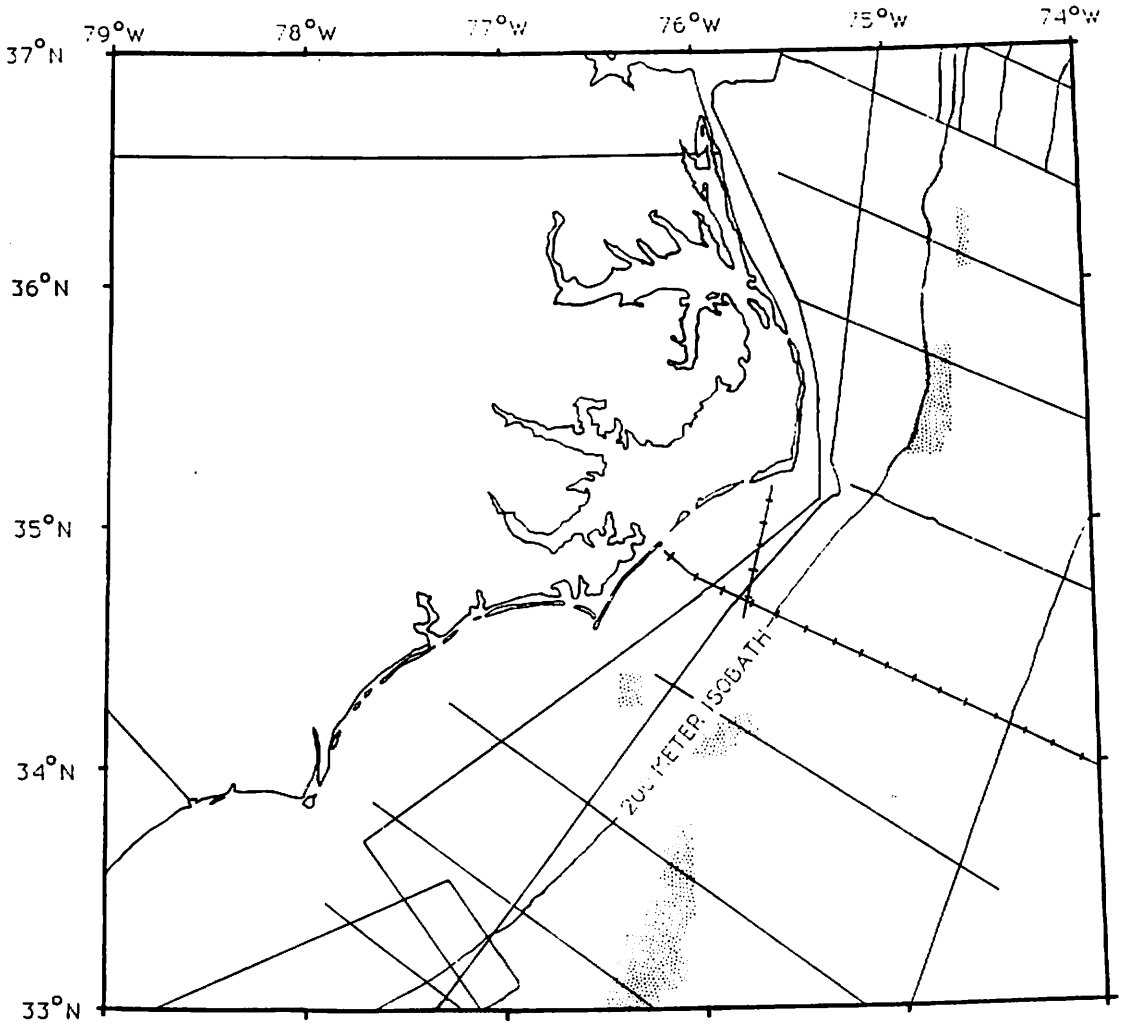
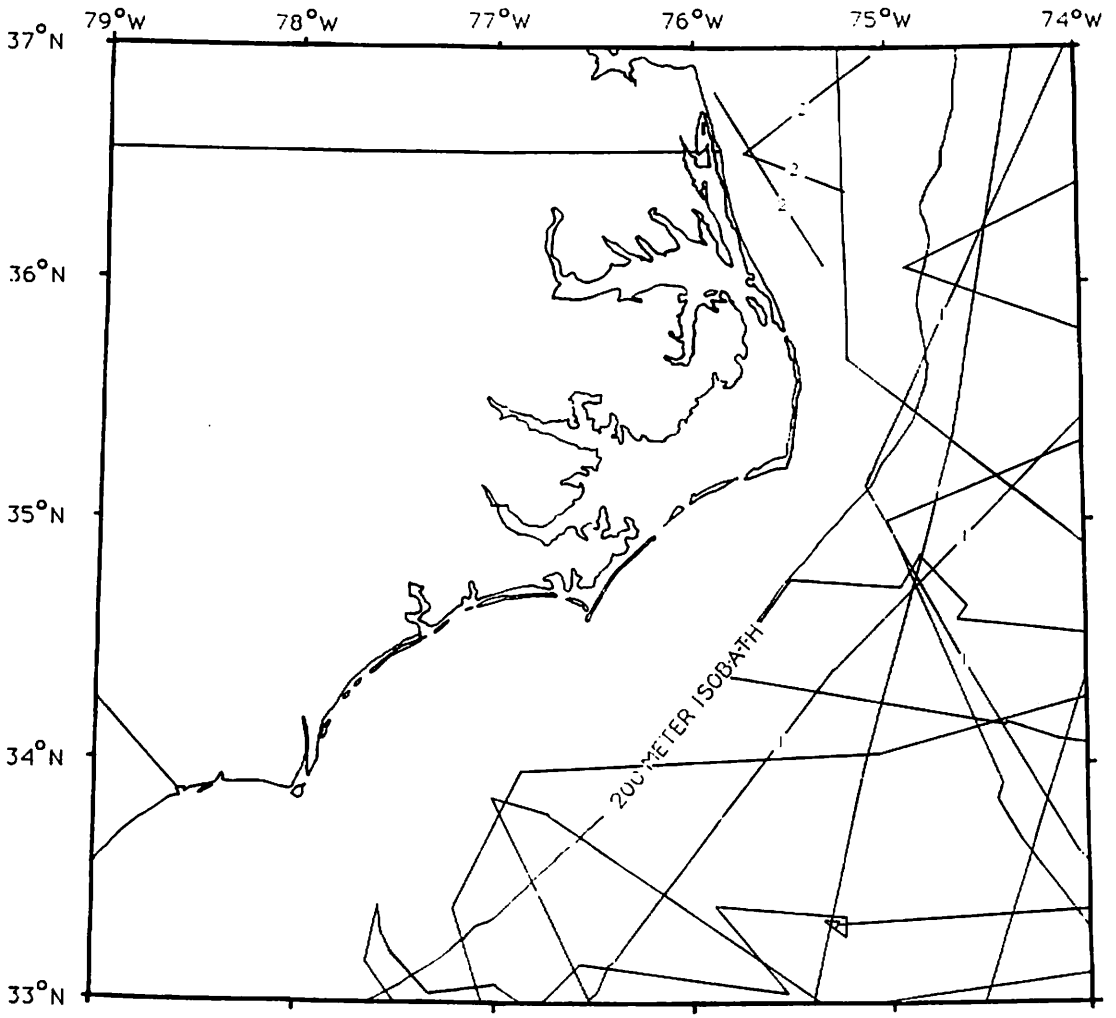
SEISMIC LINE	SHOTPOINTS	LENGTH	DEPTH	VERTICAL SCALE	ORIGINAL	
					LENGTH	WIDTH
		MILES	SECONDS	SEC/INCH	INCHES	INCHES
D-1	101-757	30.9	7.0	2.5	44	24
D-2	101-583	31.6	7.0	2.5	33	24
D-3	101-292	12.3	7.0	2.5	15	24
D-4	101-458	23.2	7.0	2.5	26	24
D-4	101-458		3.0	5.0	47	17
D-4	101-458		3.0	7.5	91	32
D-5	130-495	23.7	7.0	2.5	26	24
D-6	101-775	44.1	7.0	2.5	46	24
G-1-A	16-135	22.3	4.0	7.5	37	35
G-1-B	36-403		4.0	7.5	94	35
G-2-A	246-354	20.0	4.0	7.5	36	35
G-2-B	-26-308		4.0	7.5	85	35
G-2-C	-26-354		4.0	5.0	70	24
G-2-D	-26-354		4.0	7.5	106	37
G-3-A	88-251; 289-422	42.5	4.0	7.5	93	35
G-3-B	381-519; 588-745		4.0	7.5	93	35
G-3-C	726-834		4.0	7.5	31	35
G-3-D	88-834		4.0	5.0	132	24
G-3-E	88-834		4.0	7.5	197	37
G-4-A	119-283	23.0	4.0	7.5	49	35
G-4-B	143-508		4.0	7.5	94	35
G-4-C	119-508		4.0	5.0	72	24
G-4-D	119-508		4.0	7.5	108	37
G-5	-26-247	14.1	4.0	7.5	78	35
G-7	121-621	27.3	4.0	7.5	138	35
G-8-A	51-395	64.6	4.0	7.5	95	35
G-8-B	369-771		4.0	7.5	102	35
G-8-C	717-850		4.0	7.5	34	35
G-8-D	797-1188		4.0	7.5	101	35
G-9-A	49-188	7.7	4.0	7.5	45	35
G-9-B	49-188		4.0	5.0	30	24
G-10-A	105-176	23.7	4.0	7.5	26	35
G-10-B	158-515		4.0	7.5	91	35
G-11-A	24-343	37.8	4.0	7.5	90	35
G-11-B	296-682		4.0	7.5	99	35
G-12-A	12-287	35.9	4.0	7.5	77	35
G-12-B	223-299; 343-632		4.0	7.5	97	35
G-13	107-230	7.1	4.0	7.5	40	35
G-16	-12-77	4.6	4.0	7.5	32	35
G-19-A	9-258	28.9	4.0	7.5	71	35
G-19-B	153-493		4.0	7.5	94	35
G-22-A	59-136	28.2	4.0	7.5	22	35
G-22-B	200-357; 389-523; 668-690		4.0	7.5	94	35
G-24	92-188	5.7	4.0	7.5	34	35
W-3-A	103-292	11.9	3.0	7.5	55	29
W-3-B	103-292		3.0	5.0	37	17
W-23-A	103-526	26.1	3.0	7.5	116	32
W-23-B	103-526		3.0	5.0	77	17

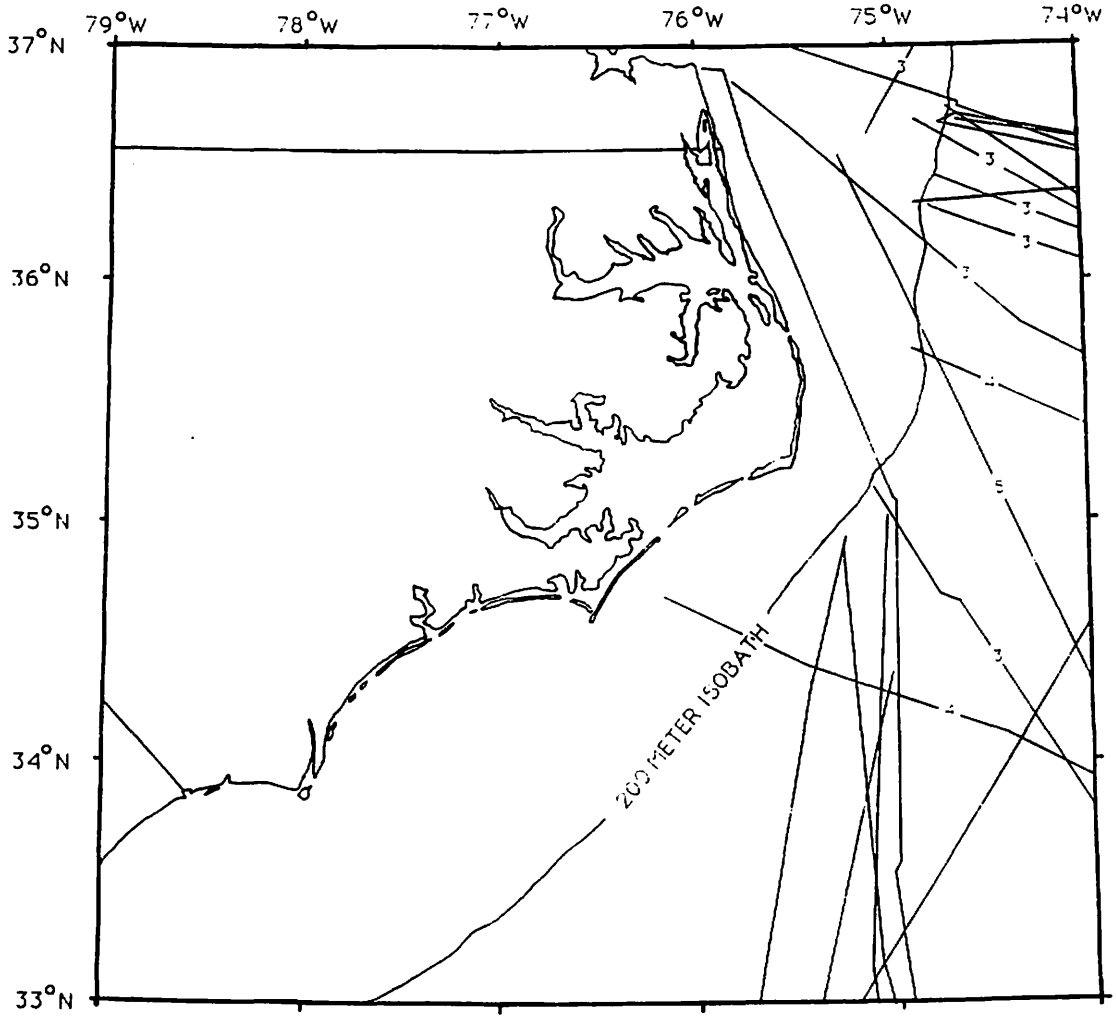
Appendix 1. Key parameters which characterize seismic lines on file at the North Carolina Geological Survey.



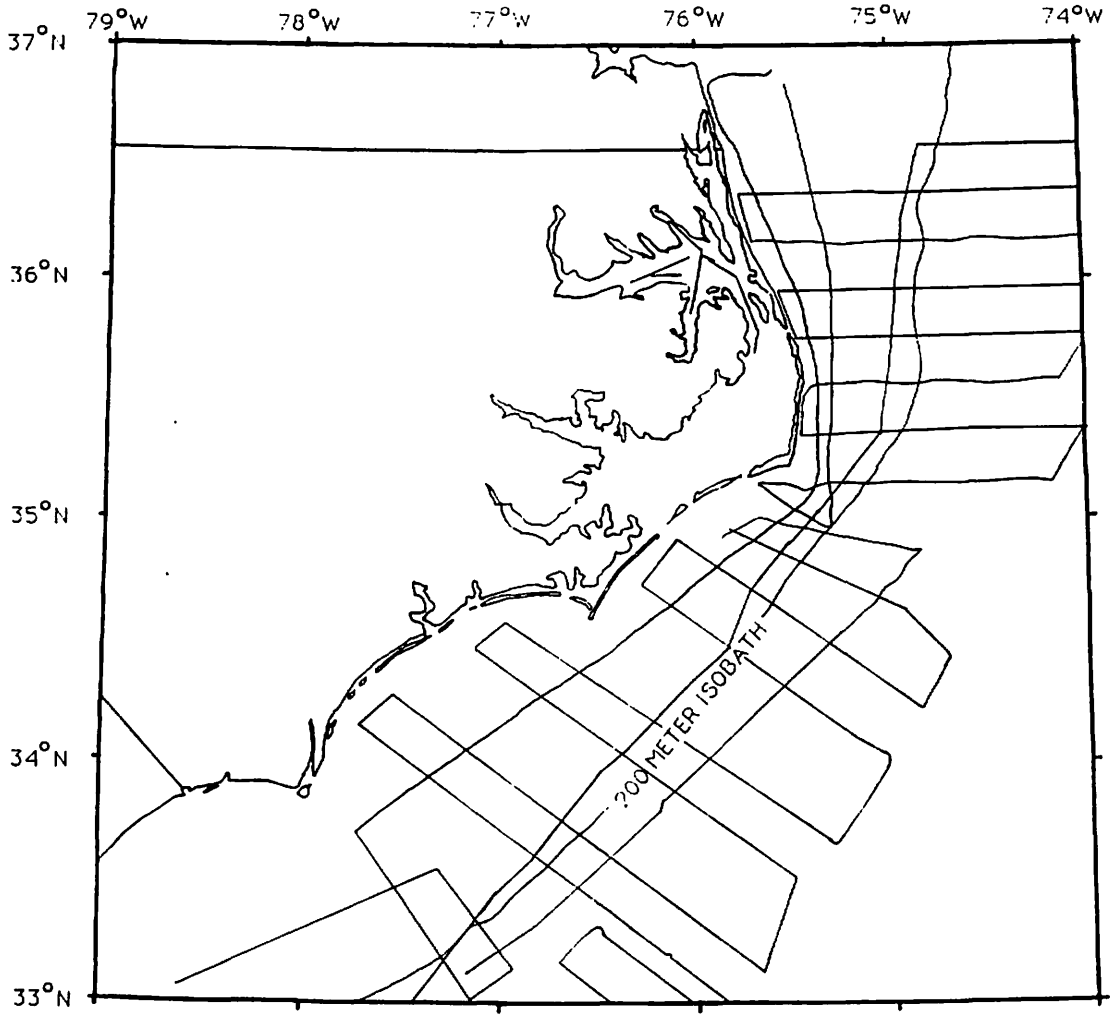
Appendix 2A. Location maps for available seismic data from the North Carolina continental shelf and adjacent offshore area. Solid lines represent tracklines of selected U. S. Geological Survey multi-channel seismic-reflection profiles from the North Carolina shelf and adjacent offshore area (P. Popenoe, written communication, 1989; NOAA/National Geophysical Data Center, written communication, 1989). Cross-hatched lines represent tracklines of U. S. Geological Survey/International Program of Ocean Drilling (IPOD) multi-channel seismic-reflection profiles. Stippled areas represent closely spaced grids of Minerals Management Services single-channel seismic reflection profiles (NOAA/National Geophysical Data Center, written communication, 1989).



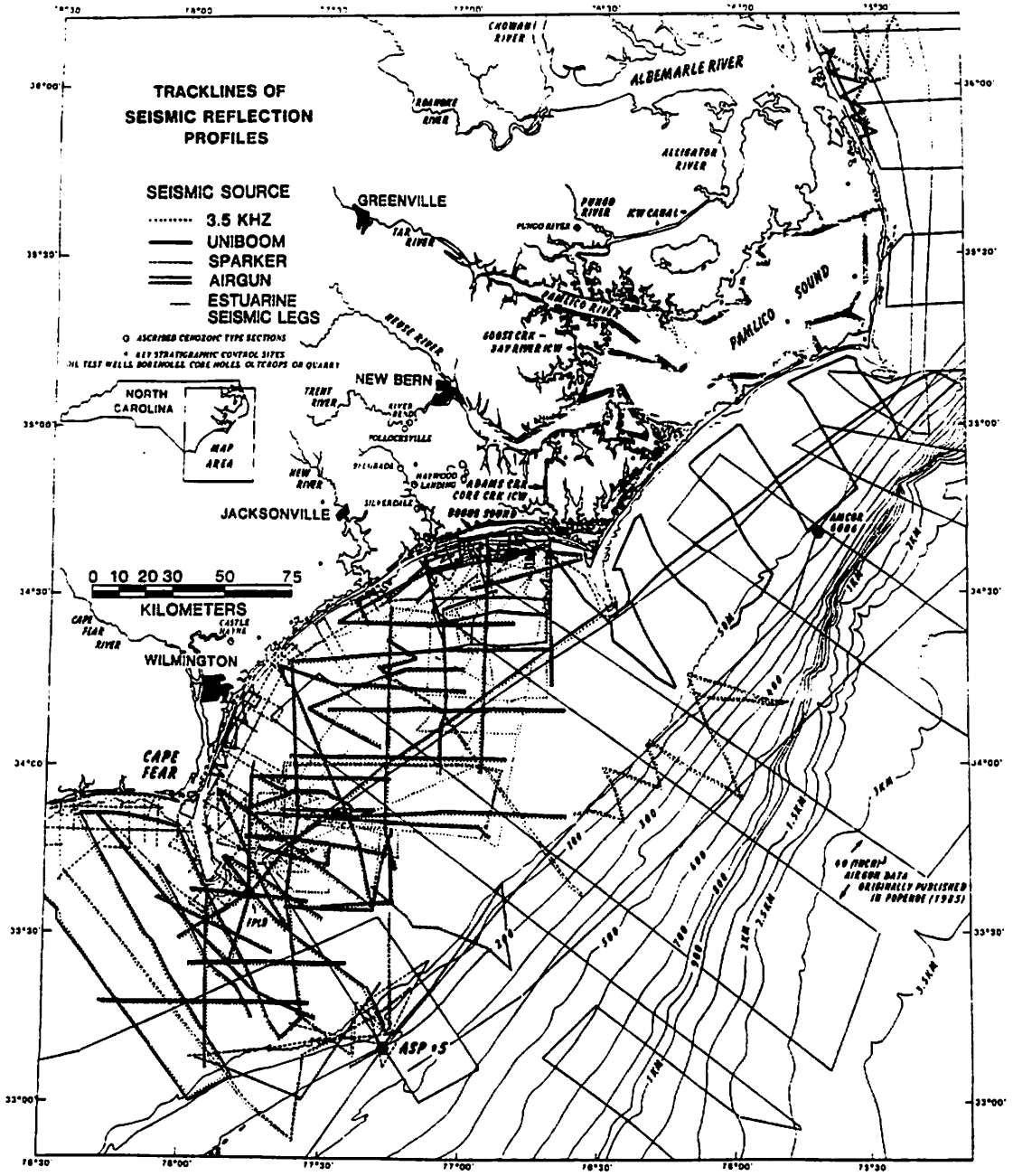
Appendix 2B. Location maps for available seismic data from the North Carolina continental shelf and adjacent offshore area. Solid lines represent tracklines of multi-channel seismic-reflection profiles from the North Carolina shelf and adjacent offshore area on file at the NOAA/National Geophysical Data Center. Tracklines without numbered labels are from Lamont-Doherty Geological Observatory, tracklines labeled with a number one are from Woods Hole Oceanographic Institute, and tracklines labeled with a number two are from the Minerals Management Service (NOAA/National Geophysical Data Center, written communication, 1989).



Appendix 2C. Location maps for available seismic data from the North Carolina continental shelf and adjacent offshore area. Solid lines represent tracklines of multi-channel seismic-reflection profiles from the North Carolina shelf and adjacent offshore area on file at the NOAA/National Geophysical Data Center. Tracklines without numbered labels are from Scripps Institution of Oceanography, tracklines labeled with a number three are from the U. S. Navy, tracklines labeled with a number four are from the National Oceanic and Atmospheric Administration, and tracklines labeled with a number five are from Texas A & M University (NOAA/National Geophysical Data Center, written communication, 1989).



Appendix 2D. Location maps for available seismic data from the North Carolina continental shelf and adjacent offshore area. Solid lines represent tracklines of selected U. S. Geological Survey single-channel seismic-reflection profiles from the North Carolina shelf and adjacent offshore area (Popenoe, 1983; Popenoe and Meyer, 1983; Popenoe and Ward, 1983; Popenoe, 1985). These data are available at NOAA/National Geophysical Data Center and additional coverage in this area is available for study at the U. S. Geological Survey at Woods Hole (Popenoe, written communication 1989).



Appendix 2E. Location maps for available seismic data from the North Carolina continental shelf and adjacent offshore area. Tracklines of seismic-reflection profiles on file at the Department of Marine, Earth, and Atmospheric Sciences Seismic Data Library at North Carolina State University (map from Stephen W. Snyder, written communication, 1989).