Date: November 1, 1994

To:	Arko, Bob	L-DEO Data Center
	Chayes, D.	L-DEO Hydrosweep
	Hayes, D.	L-DEO Associate Director
	Mutter, J.	L-DEO Interim Director
	MARSCICO,	L-DEO Marine Department
	Ljunggren, Paul	L-DEO Marine Department
	Stennett, J.	L-DEO Science Officer
	Francis, Bruce	L-DEO Science Officer
	Robinson, W.	L-DEO Data Reduction
	Science Officer	EWING Science Files
	Captain	EWING Captain Files
	Chief Engineer	EWING Engineer Files

RESEARCH CRUISE REPORT

R/V MAURICE EWING, LEG 94-10

Deep Seismic Investigation of the Continental Crust, Bering and Chuckchi Seas, Alaska

P.I. Dr. Simon Klemperer, Stanford University
Dates: 6 August to 1 September, 1994
Ports: Dutch Harbor to Dutch Harbor, AK

Michael Rawson
Marine Department

RV *Maurice Ewing* Cruise EW94-10

Cruise Report
6 August 1994 - 1 September 1994

Deep Seismic Investigation of the Continental Crust,
Bering and Chukchi Seas, Alaska

Brian K. Galloway and Shipboard Scientific Party, EW94-10

CONTENTS

ABSTRACT

Stanford University, in conjunction with the U.S. Geological Survey, and with participation by the Institute of the Lithosphere and the Institute of Oceanology of the Russian Academy of Sciences, and the Geodynamics Research Institute of Texas A&M University, conducted deep seismic investigations of the continental crust beneath the Bering and Chukchi Seas, Alaska, during the month of August, 1994 (*see* figures 1 through 4). The data was recorded to two-way travel-times of 15 to 23 seconds, with 50 to 75 meter shot spacing.

Two north-south transects were profiled. The eastern transect extended from 58°50'N, 169°32'W, well within the continental shelf of the Bering Sea, north of the Pribilof Islands, to just south of the shelf edge north of Barrow, Alaska, at 71°49'N, 154°33'W. Ice prevented continuation of the line beyond the shelf edge. The western transect extended from the central Chukchi Sea, well within the shelf at 71°23'N, 163°00'W, into the Aleutian basin at 58°00'N, 178°30'W, near Navarinsky Canyon. An additional short line crossing over the Beringian margin a second time was recorded near Zemchug Canyon east of the western transect.

The profiles cross important strike-slip faults, possible terrane boundaries, two continental margins, and several Cretaceous/Tertiary sedimentary basins (Norton, Hope, Chukchi, and Navarin Basins). Together with the preceding cruise EW94-09, the profiles provide a continuous transect across the North American continent, from the Pacific to the Arctic Ocean (*see* figures 7 through 9 for data examples).

Most of the multi-channel seismic (MCS) data is of high quality, but bad weather, strong currents, and recording problems sometimes presented difficulties during data acquisition. Gravity, magnetic, and sonobuoy data were also recorded along the profiles. Wide-angle recording was done in conjunction with the seismic profiling, at recording sites located along the central west coast of Alaska and the Chukchi Peninsula, as well as on islands in the Bering Strait and Bering Sea.

SCIENTIFIC AND TECHNICAL PERSONNEL

Scientific Party

Klemperer, Simon L. (Chief Scientist)	Stanford University, USA
Childs, Jonathan R.	Pacific Marine Geology, USGS, USA
Galloway, Brian K.	Stanford University, USA
Bogdanov, Nikita A.	IL/RAS, Russia[1]
Gnibidenko, Helios	IO/RAS, Russia[2]
Plake, Terri D.	Western Washington University, USA
Tepano, Arsenio	Bellingham, Washington, USA
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Technical Personnel

Stennett, Joseph N. (Science Officer)	LDEO, USA[3]
Robinson, William J.	LDEO, USA
Donaldson, Charles W.	LDEO, USA
Maiwiriwiri, Ropate	LDEO, USA
DiBernardo, John G.	LDEO, USA
Gutierrez, Carlos	LDEO, USA
Phillips, Octavio	LDEO, USA
McKenna, Brian L.	Digicon Inc., USA

[1]Institute of the Lithosphere, Russian Academy of Sciences
[2]Institute of Oceanology, Russian Academy of Sciences
[3]Lamont-Doherty Earth Observatory

Ship's Personnel

Young, Ian W.	Master
Mello, Louis J.	Chief Mate
Landow, Mark C.	2nd Mate
Phillips, David L.	3rd Mate
Santini, John J.	Boatswain
Barros, Larry W.	A/B
Golenski, Kenneth D.	A/B
Scanlan, Christopher J.	A/B
Spangler, Scott	O/S
Wyatt, Rickey R.	O/S
Karlyn, Albert D.	Chief Engineer
Tucke, Matthew J.	1st Engineer
Van Duyne, Matthew J.	2nd Engineer
Greenfield, Todd J.	3rd Engineer
Maker, Greenleaf C.	Oiler
Christian, Mark R.	Oiler
Uribe, Guillermo F.	Oiler
Newton, Gil E.	Wiper
Schwartz, John H.	Electrician
Paloney, Frank	Steward
Smith, John S.	Cook
Moqo, Luke	Utility
Powell, Robert V.	Radio Operator

ITINERARY

leave Dutch Harbor, Alaska, USA	6 August 1994
deploy MCS streamer and airguns	7 August
begin shooting northbound transect	8 August
end of northbound transect, retrieve MCS gear	18 August
deploy MCS gear	19 August
begin shooting southbound transect	20 August
end of southbound transect; retrieve MCS gear	30 August
arrive Dutch Harbor, Alaska, USA	1 September 1994

DATA ACQUISITION AND EQUIPMENT

Seismic Recording System

A DMS-2000 computing system (Digicon Geophysical Corporation) was used for seismic recording. The DMS-2000 is a distributed network of processors comprising a number of subsytems responsible for various aspects of recording seismic data. The system is capable of recording seismic data from as many as 3 streamers each configured with 252 channels. The seismic data are recorded on high density 3480 cartridge tapes. See the Appendix for more information on the DMS-2000 recording system.

The hardware for cruise EW94-10 consisted of a digital 180-channel streamer (Digicon Geophysical Corporation), 4 km in length, with 25-meter hydrophone spacing. Only 160 channels of the streamer were used during profiling at an optimal depth of 15 meters. The near receiver offset was 200 m, and the far receiver offset was 4175 m. The source was a 8355 in^3 (137.7 liters), 20-chamber airgun array (*see* figure 5 for array configuration). The synthetic signature of the R/V Maurice Ewing's airgun array for cruise EW94-10 is shown in figure 6.

Gravimeters

Two gravimeters were used. A Bell Aerospace BGM-3 marine gravity meter, logging every second, and a Bodenseewerks KSS-30 marine gravity meter, logging every 6 seconds.

Magnetometer

A Varian V75 magnetometer, logging every 6 seconds.

Bathymetry

An Atlas Hydrosweep DS, logging every second.

Navigation

A Magnavox MX-4200D Global Positioning System and Ashtech 3D CPS with speed log information provided by a FURUNO CI-30 three-axis, doppler speed log/current profiler.

Sonobuoys

Sparton Electronics 53B/8W62 disposable sonobuoys. They were shot off the port and starboard sides by using air-pressure launchers.

APPROXIMATE WAYPOINTS AND MILEAGE FOR THE MAIN MCS TRANSECTS

Northbound Profile

SOL	58° 50' N	169° 32' W	*line-tie with EW94-09 (Delaware/LDEOcruise)*
			265 nautical miles
WP2	63° 13' N	168° 26' W	*St. Lawrence Island, Northease Cape*
			167 nm **
WP3	66° 00' N	168° 17' W	*Diomede Island*
			121 nm **
WP4	68° 00' N	167° 35' W	*Pt. Hope*
			64 nm
WP5	69° 00' N	166° 35' W	*Cape Lisburne*
			73 nm
WP6	70° 00' N	164° 35' W	*Pt. Lay*
			44 nm
WP7	70° 30' N	163° 00' W	*Icy Cape*
			64 nm
WP8	70° 52' N	160° 00' W	*Wainwright*
			88 nm
WP9	71° 34' N	156° 00' W	*Barrow*
			21 nm
EOL	71° 49' N	154° 32.5' W	*ice edge*
			total: 915 nm = 1695 km

**Some cross-line control may be available south of St. Lawrence Island and in outer Kotzebue sound from profiling while circling for more than 24 hours during gales. (*see* figure 2)

(transit without profiling)

Southbound Profile

SOL	71° 23.1' N	163° 00' W	*ice edge*
			143 nm
WP2	70° 00' N	168° 50' W	*northwest of Cape Lisburne*
			264 nm
WP3	65° 36' N	168° 50' W	*Diomede*
			11 nm
WP4	65° 26.5' N	169° 03' W	*dog-leg around Russian waters*

			119 nm
WP5	63° 55' N	172° 00' W	*St. Lawrence Island, Northwest Cape*
			254 nm
WP6	60° 11.4' N	176° 16' W	*Navarin Basin COST Well*
			81 nm
WP7	59° 00' N	177° 31.9' W	*Navarin Ridge*
			67 nm
WP8	58° 00' N	178° 30' W	*Aleutian Basin*
			71 nm
WP9	57° 30' N	176° 30' W	*Aleutian Basin*
			68 nm
WP10	58° 29.5' N	175° 28.5' W	*Zemchug Canyon earthquake epicenter*
			33 nm
EOL	59° 00' N	174° 56.3' W	*continental shelf*

total: 1111 nm = 2059 km

overall total: 3754 km

SHOOTING PARAMETERS

Line	Shot spacing	Record length		Location of first shot-point
1A	***	***	1A was not recorded	***
1B	50 m	16 sec	circle at EOL	58° 50' N 169° 32 ' W
1C	50 m	15 sec		60° 20.5' N 169° 10' W
1D	75/50 m	15 sec	line ended during circle south of St. Lawrence during gale	61° 21.3' N 168° 55' W
1E	75 m	22 sec		62° 15.4' N 168° 40.4' W
1F	75 m	18 sec		65° 26' N 168° 19' W
1G	75 m	20 sec		66° 42.6' N 168° 2.8' W
1H	50 m	16 sec		67° 9.7' N 167° 53.5' W
2A	50 m	16 sec	circle at EOL	70° 30.7' N 162° 55.1' W
2B	50 m	16 sec	shot while circling off Icy Cape	***
2C	50 m	16 sec		70° 32.3' N 162° 50.3' W
2D	75 m	20 sec		70° 50.7' N 160° 8.5' W
2E	***	***	2E was not recorded	***
2F	75 m	18 sec	end of northbound transect at ice edge	71° 23.1' N 157° 8.5' W
3A	50 m	16 sec		71° 23' N 163° 0' W
3B	50 m	16 sec	circle at EOL	70° 30.9' N

				166° 42.5' W
3CC	50 m	17 sec	shot while circling near Diomede	65° 33' N
				168° 50' W
3D	50 m	17 sec		65° 36.8' N
				168° 48.4' W
3E	75 m	23 sec		58° 0' N
				178° 30' W
3F	50 m	17 sec	end of southbound transect	57° 30' N
				176° 28.5' W

Strong northward currents frequently prevented the use of 50 meter shot spacing in the northern-bound line. Thus, 75 meter shot spacing was used. The same currents allowed the use of 50 meter shot spacing on the south-bound line. Refer to figure 2 for approximate line locations.

During profiling we circled five times:
1/ at EOL 1B due to operator error;
2/ south of St. Lawrence during line 1D due to bad weather;
3/ in outer Kotzebue Sound during line 1H due to bad weather;
4/ north of Icy Cape between lines 2A and 2C, due to problems with the recording system;
5/ south of Little Diomede between lines 3B and 3D, due to problems with the recording system.

All other line changes were made while profiling, resulting in loss of about 5 minutes data on each occasion. All turns at waypoints were made as inside turns with continuous shooting, except where previously noted as circles.

WIDE-ANGLE ON-LAND STATIONS

Wide-angle recording was done in conjunction with the seismic profiling (*see* figure 1). The instruments used were Mark Products L-28, 3-component geophones, with a resonant frequency of 4.5 Hz.

Station Name	Latitude (N) Deg. Min.	Longitude (W) Deg. Min.	Elevation (m)
Lietnik	63 19.60	168 57.75	5
Gambell	63 46.50	171 43.60	2
King Island	64 58.75	168 03.00	300
Tin City	65 33.70	168 55.25	80
Little Diomede	65 44.95	168 54.75	305
Point Hope	68 21.25	166 47.70	1
Cape Lisbourne	68 52.60	166 06.80	80
Point Lay	69 43.90	163 01.10	2
Providenya	64 26	173 13	??
Novo Chaplino	64 35	172 51	??
Lavrentiya	65 35	171 00	??

SONOBUOYS

Sonobuoy	Line, FFID	Lat. N (deg)	Long. W (deg)
46	1B, 2754	60.05	169.243
47	1C, 280	60.433	169.147
48	1C, 1331	60.905	169.03
49	1D, 155	61.392	168.917
50	1D, 757	61.793	168.82
51	1D, 1874	62.533	168.613
52	1E, 539	62.545	168.64
53	1E, 556	63.227	168.413
54	1E, 1793	63.383	168.417
55 (dud)	1E, 3225	(not recorded)	(not recorded)
56	1E, 3242	64.345	168.347
57	1E, 3873	64.773	168.352
58 (dud)	1E,(not recorded)	65	168
59	1E, 4659	65.292	168.31
60	1F, 1067	66.10	168.25
61	1F, 1901	66.647	168.072
62	1H, 3249	66.892	167.98
63	1H, 4525	67.453	167.788
64	1H, 5218	67.757	167.683
65	1H, 6062	68.118	167.47
66	1H, 7027	68.523	167.082
67	1H, 7277	68.625	166.98
68	1H, 7520	68.728	166.872
69	1H, 9140	69.353	165.89
70 (dud)	(not recorded)	(not recorded)	(not recorded)
71	1H, 10070	69.693	165.203
72	2A, 122	70.515	162.897
73	2D, 1222	71.202	158.087
74	3A, 1472	71.028	164.553
75 (dud)	3A, 1848	70.93	164.972
76	3B, 2726	69.715	168.835
77	3B, 4051	69.127	168.83
78	3B, 4236	69.04	168.833
79	3B, 4597	68.882	168.837
80	3B, 6630	67.983	168.833
81	3D, 944	65.535	168.912
82	3D, 1561	65.093	169.738
83	3D, 1759	65.027	169.868
84	3D, 3730	64.355	171.172
85	3D, 5234	63.823	172.097

86	3D, 5465	63.732	172.223
87	3D, 7583	62.907	173.212
88	3D, 9499	62.157	174.08
89	(non-existent)		
90	3D, 11118	61.517	174.813
91	3D, 16638	59.367	177.143
92	3D, 18046	58.812	177.713
93	3F, 2511	58.45	175.522
94	3F, 3199	58.717	175.228

DATA AVAILABILITY

Seismic and Sonobuoy
The seismic and sonobuoy data is obtainable through Stanford University.
Contact:
Simon Klemperer, Department of Geophysics, Mitchell Building, Stanford University, Stanford CA 94305-2215 (klemp@pangea.stanford.edu) for further information. After August, 1997, all data will be permanently filed at the National Geophysical Data Center, Dept. 930, 325 Broadway, Boulder, CO, 80303-3328 (ph: 303-497-6277, fax: 303-497-6513, internet: info@mail.ngdc.noaa.gov).

Gravity and Magnetic
Gravity and magnetic data is available from Lamont-Doherty Earth Observatory, Columbia University. Contact:
Bob Arko (mggdb@lamont.ldeo.columbia.edu)

3.5 kHz depth-sounder
3.5 kHz depth-sounder records are available from Lamont-Doherty Earth Observatory, Columbia University. Contact:
Bob Arko (mggdb@lamont.ldeo.columbia.edu)

Wide-angle records
Wide-angle records will be available from IRIS Data Management Center one year after acquisition. For details of stations in Alaska contact:
Tom Brocher, USGS, Mail Stop 979, 345 Middlefield Road, Menlo Park, Ca, 94025 (brocher@andreas.wr.usgs.gov).
For details of stations in Russia contact:
David Stone, Geophysical Institute, P. O. Box 7320, University of Alaska, Fairbanks, AK, 99775-7320 (ffdbs@aurora.alaska.edu)

APPENDIX

Notes on DMS-2000 seismic recording system and SEG-D data format.

The DMS-2000 records demultiplexed seismic data in a standard SEG-D format (Geophysics, Vol. 59, No. 4, April 1994, pp. 668-684), using a 20-bit (2.5 bytes per sample) recording format. However, data logged from peripheral systems (bird controller, gun controller, navigation, etc.) are not written to the SEG-D header blocks, but are rather recorded in a special auxiliary data trace, referred to in the Digicon documentation as SEGD/Trace0 ("trace zero"). The SEG-D General Header (the header that accompanies each shot record), does contain the shot number and shot time to the nearest second.

For EW94-10, the DMS-2000 was configured to record 184 data channels from 46 four-channel digitizing modules (or "cans"). Only 40 of these cans were actually in the streamer, resulting in 160 active channels, numbered 1-160. Channel 1 is the far channel, 160 the near channel. Two channels on-board ship (177 and 178) were used to record the sonobuoy receivers. The remaining channels (161-176, 179-180) are physically on tape, but contain no data. Trace0 consists of a 4051-byte data trace preceding the demultiplexed seismic data, with a channel designation -1. It is flagged by the system as an auxiliary trace.

The DMS-2000 also writes a secondary data tape, referred to as the NAVLOG tape. This is recorded in format identical to the SEG-D data tape, but contains only three channels - Trace0 and two data channels. For EW94-10 these were channels 150 and 177, a relative near-trace and a sonobuoy channel. (Channels to be forked to the NAVLOG tape are selected in the CEO SOL/EOL Auto-Start-End menu of the DMS-2000 system.)

The basic layout of the SEG-D tape is: size in bytes

General Header	-		96 (3 32-byte blocks)
IBG	I		
Trace0 record	I		4051 (variable-length sections)
IBG	I	S	
Data Channel1	I	H	RECL*2.5 + 20-byte trace header
IBG	I	O	
Data Channel2	I	T	
IBG	I		
:	I	1	
:	I		
Data Channel 184	I		
IBG	I		
EOF	-		
General Header	-		
IBG	I		
Trace0 record	I	S	
IBG	I	H	
Data Channel 1	I	O	
:	I	T	
:	I		
Data Channel 184	I	2	
IBG	I		
EOF	-		
	:		
	:		
	-		
	I	S	
	I	H	
	I	O	
	I	T	
	I		
	I	N	
EOF	-		
EOT			

The General Header consists of three 32-byte blocks, and contains the following relevant fields:

byte number	data
1- 2	FFID
3- 4	SEG-D format code (8015 - 20-bit binary demux)
5- 6	not used
7- 8	shotpoint
9-10	?? (791)
11	year (94)
12-13	day of year
14	shot hour (GMT)
15	shot minute "
16	shot second "

These values are recorded in Binary-Coded Decimal (BCD) notation, and are therefore recognizable in a hex dump. The day/hour/minute/second fields above are standard SEG-Y, but the shotpoint location is not defined by the standard. Software that reads SEG-D, such as ProMax or DISCO, will therefore probably read the shot times, but not the shotpoints. The location of the shotpoint field must be explicitly defined in the input module. For example, in ProMax, it is necessary to select "Remap SEGD main header values" in the SEG-D input module, and indicate something like:

Input/override main header entries SOURCE,,4B,,,6.5/

where 6.5 indicates the starting location in the header record for the 4-digit BCD value for shotpoint, which is mapped onto the header value SOURCE. The odd value (6.5) for starting location is a peculiarity of ProMax. ProMax SEGD input also converts the shot time to absolute seconds stored in a header word TIM_SHOT. You may choose to explicitly identify the time by hour, minute, and second, with an Input/override entry like:

SOURCE,,4B,,,6.5/HR_SHOT,GMT SHOT HOUR,2B,,,13.4/MIN_SHOT,
GMT SHOT MINUTE,2B,,,14.5/SEC_SHOT,GMT SHOT SECOND,2B,,,15.5/

Trace0 contains a wealth of information about the system (e.g., seismic bird information, gun shooting parameters), much of which is also available from other shipboard logging systems. Trace0 data is not a accessible from conventional SEGD input software; for access to it, one is advised to use John Diebold's segd_dump program, which reads and reformats to disk various selected portions of Trace0 (Internet address: johnd@lamont.ldgo.columbia.edu). Of course, dumping the Trace0 records from the NAVLOG tapes is much more efficient than reading the data tapes.

A note regarding the Trace0 positional information.

Navigational data is passed from the navigational computer aboard the Ewing ("Moray") to the DMS-2000 for inclusion in Trace0, where it is stored in Section 11, the "Magnavox Nav Data Block". (Digicon uses Magnavox navigational systems on their vessels). This 211-byte navblock contains latitude and longitude fixes for each shot, which can be read with segd_dump. These positions, however, are "real-time" solutions that have not been adjusted or corrected by the post-processing that is done daily on-board the vessel.

The 20-byte individual Demux Trace Headers which precede each data trace have little information of use to the processor, nor does the SEG-D standard suggest that they should.

Tape Errors

The 3480 tape drives suffered from recurring, persistent errors throughout EW94-10. These errors were manifested by SQRT 84 error message on the CSRU monitor and in the *.rue error log (see below). The problem would also cause a tape drive to fail on changeover of tapes as though the alternate drive was not loaded. The problem was more persistent on drive 1, but was also attributed to problems with the tapes themselves. Some boxes of tape were found to be more susceptible to these errors.

These SQRT errors also resulted in two shot records being concatenated into one file, with the second record overwriting some portion of the previous one. These files have a variable number of traces, in excess of the normal 184. The processing flow must be able to read these abnormal files, and pad the channels to create normal ensembles.

CEO/CSRU and TAGS logs

The DMS-2000 system also maintains logs and error files of the recording system (CSRU) and the airgun control system (TAGS). The CSRU files are named 'line_id'.rul and 'line_id'.rue for the log and error files, respectively. The corresponding TAGS files are 'line_id'.tal and 'line_id'.tae. All of the information in the TAGS error file is repeated in the TAGS log file, while the CSRU error and log files are complementary. These files are written to DOS floppy disks with the CEO File Handler.

Precise shot timing and location

Processed GPS shot locations and shot-times (precise to 1 ms from the GPS receiver) are available in a separate file, but are not contained in the SEG-D records.

LIST OF FIGURES

Figure 6. (page 27)
(top) Synthetic signatures for the R/V Maurice Ewing's airgun array, compared to that used by Digicon's GEOTIDE while shooting the EDGE Cook Inlet transect. The latter has superior peak power, but (bottom) the Ewing's array has equivalent power at frequencies below 40 Hz. The Ewing synthetic is calculated for a source similar, but not precisely identical, to that used for cruise EW94-10. (From S. McGeary and J. Diebold, unpublished proposal to the National Science Foundation.)

Figure 7. (page 28, foldout)
Example of lower-crustal layering (here, the base is at approximately 11 seconds) observed within the seismic dataset. This is located over the Herald Arch and a portion of the Hope Basin. This is line 3B, ffid 3100-4250, situated in the Chuckchi Sea. Time is in seconds, and the numbers across the top are ffid numbers. The data is "constant offset" data. Each trace is actually an 8-fold stack of traces at offsets ranging from 625 m to 800 m. Some additional processing has been applied to enhance the images when plotting.

Figure 8. (page 29, foldout)
Example of mid- and lower-crustal reflectivity observed within some parts of the seismic constant offset dataset (here, the depth of the bottom of the reflectivity increases to the right from 12.5 seconds at ffid 8000, to 13 seconds at ffid 9500). This is line 1H, ffid 8000-9500, near Point Hope/Cape Lisburne, located over the Colville foredeep. The data is "constant offset" data. Each trace is actually an 8-fold stack of traces at offsets ranging from 625 m to 800 m. Some additional processing has been applied to enhance the images when plotting.

Figure 9. (page 30, foldout)
Example of the Beringian passive margin crossed within the seismic dataset. The top of the oceanic crust in the Aleutian basin can be seen at 8 seconds at the southern end of the profile. The southern portion of the Navarin Basin is seen at ffid 2500-2700 on the shelf edge. This is line 3F, ffid 1200-2700. The data is "constant offset" data. Each trace is actually an 8-fold stack of traces at offsets ranging from 625 m to 800 m. Some additional processing has been applied to enhance the images when plotting.

Figure 1

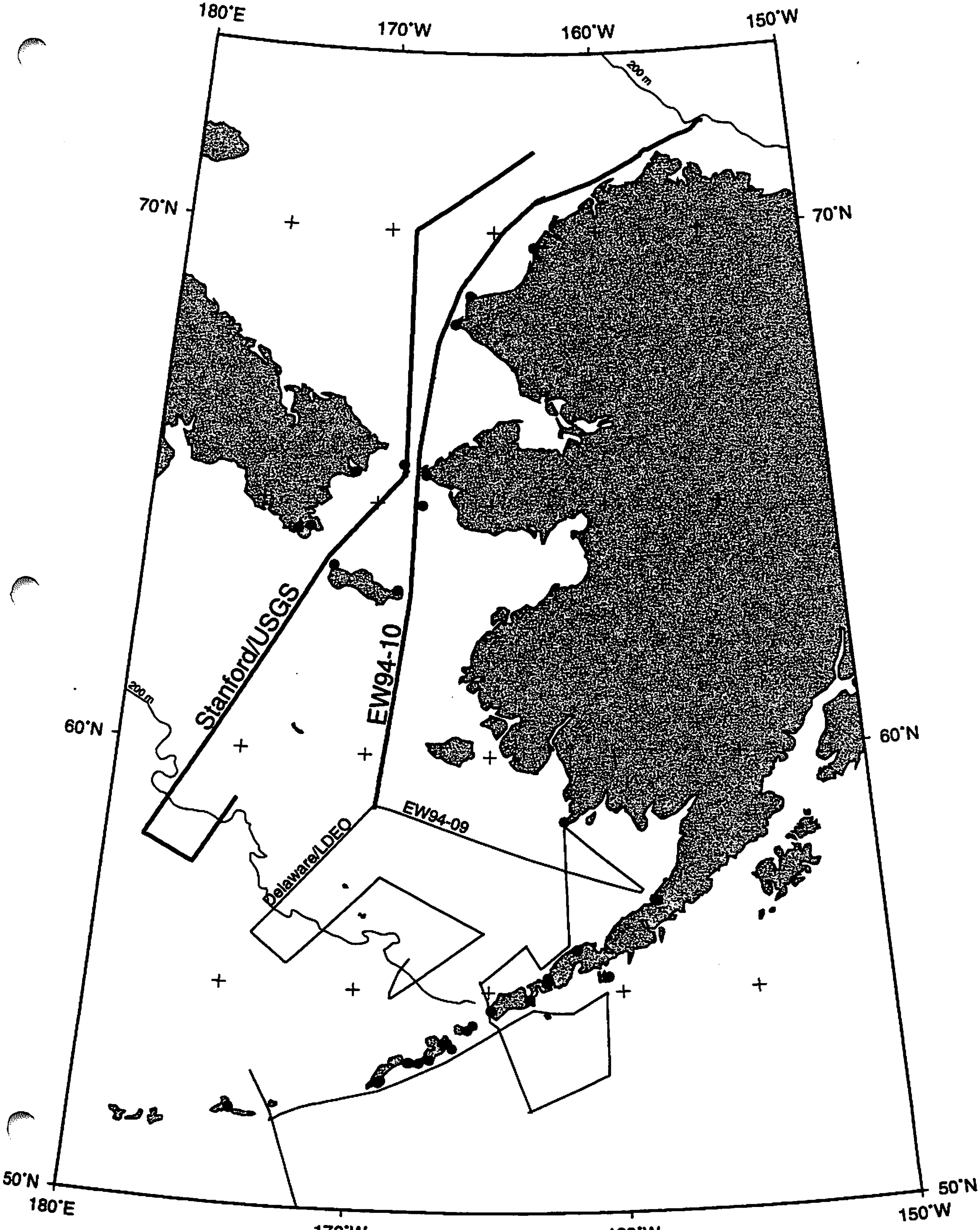
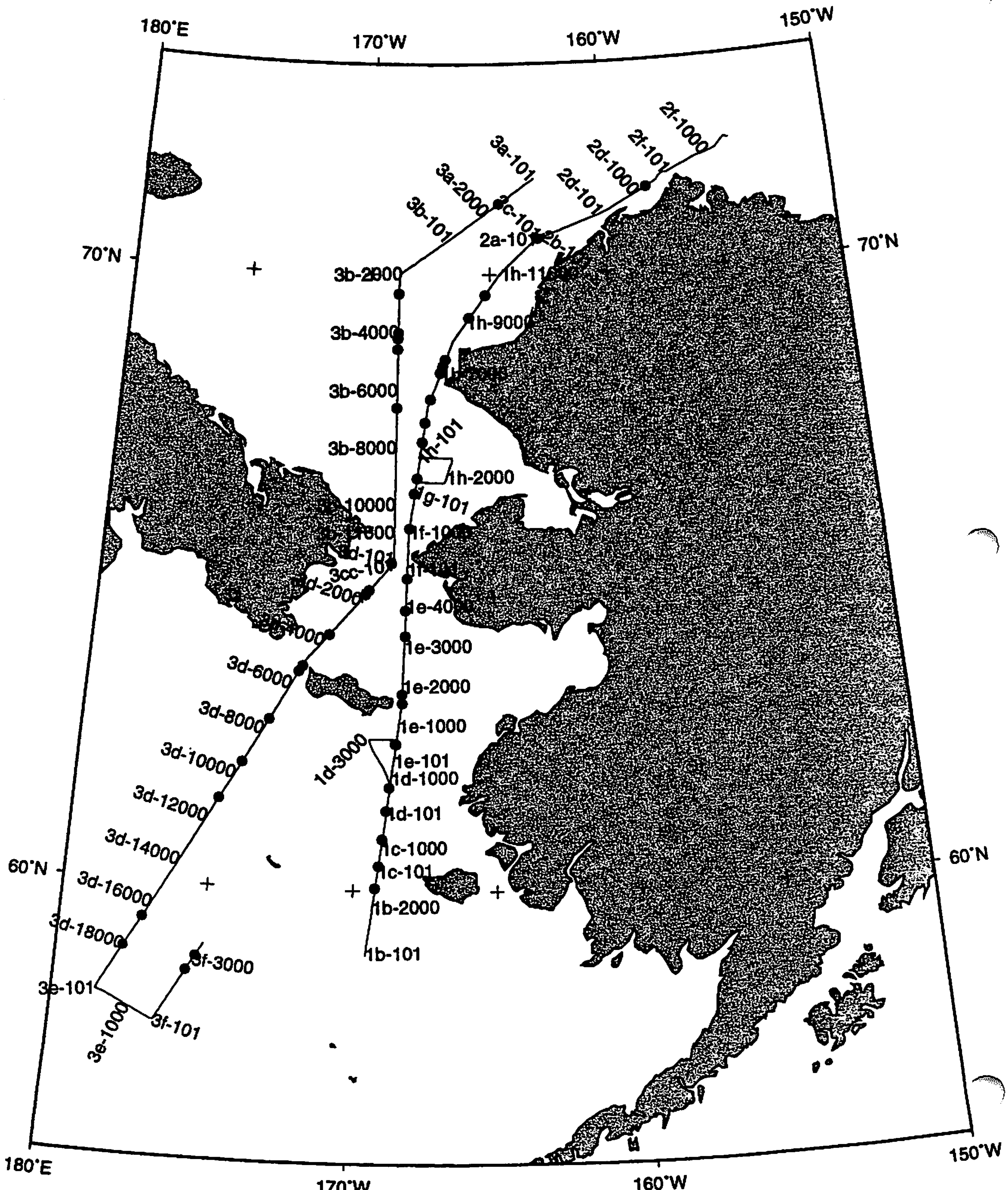

180°E
170°W
160°W
150°W
200 m
70°N
70°N
60°N
60°N
50°N
50°N
180°E
170°W
160°W
150°W
Stanford/USGS
EW94-10
EW94-09
Delaware/LDEO
200 m

Figure 2


180°E
170°W
160°W
150°W
70°N
60°N
3a-101
3a-2000
3b-101
2f-1000
2f-101
2d-1000
2d-101
2a-101
3b-2000
3b-4000
3b-6000
3b-8000
1h-9000
1h-2000
1e-3000
1e-2000
1e-1000
1e-101
1d-3000
1d-1000
1d-101
1c-1000
1c-101
1b-2000
1b-101
3d-6000
3d-8000
3d-10000
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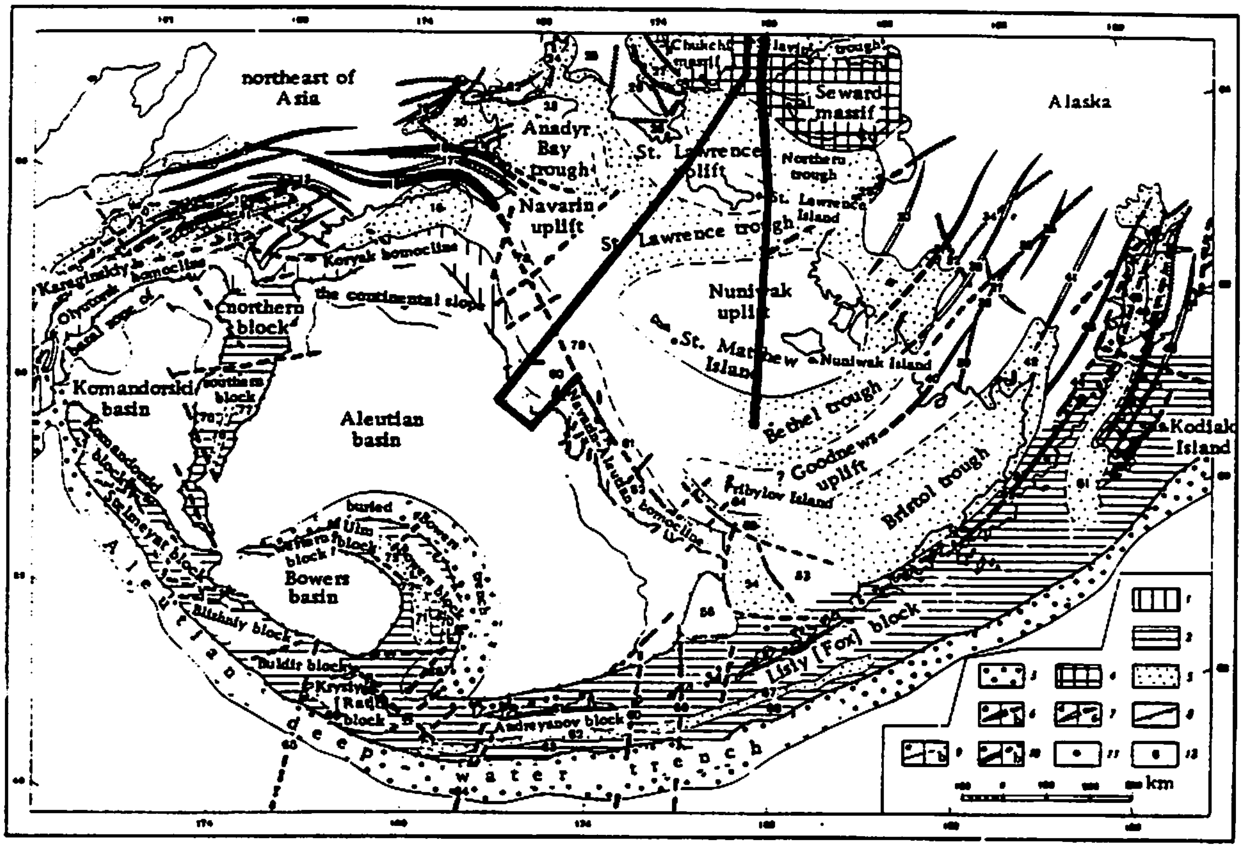
3d-14000
3d-16000
3d-18000
3e-101
3e-1000
3f-3000
3f-101

Figure 3.



1) continental slope; 2) geanticlinal uplifts; 3) trenches; 4) median massfis; 5) troughs (inherited and superimposed); 6) anticlinoria and anticlinal zones: a) identified from several lines of evidence; b) probable; 7) synclinoria and synclinal zones: a) identified from several lines of evidence; b) probable; 8) boundary of continental structural elements; 9) boundary of smaller structural elements: a) identified from several lines of evidence; b) probable; 10) faults: a) identified; b) probable; 11) volcanic structures; 12) Ordinal numbers of some of the structural elements: Anticlinoria and anticlinal zones: 1) Ust-Kamchatka; 2) Ozernovsk; 4) Karaginsk; 9) Enchavayam; 10) Pylga; 14) Olyutorsk; 15) Khatyrka; 18) Tamvatney; 19) Rarytkin; 22) Zolotogorsk; 31) Rubi; 35) Tanana; 40) Goodnews; 43) Talkitna; 47) Seldovia; 49) Kodiak; 52) Aleutian; 56) Unalashka; 61) Adakh; 68) Amchitka; 74) Komandorsk. Synclinoria and synclinal zones: 3) Litke; 6) Av'insk; 8) Velikorechensk; 11) Pakhacha; 13) Ukelayat; 17) Alkatvaam; 30) Yukon-Koyukuk; 33) Kuskokwim; 37) Shotgun; 41) Alaska range; 45) Matanuska; 48) Chugach; 50) Kodiak. Uplifts: 21) Tumansk; 23) Anaut; 26) Kurupka; 28) Senyavino; 63) Unimak; 55) Umnak; 58) Unalashka; 63) Holy; 66) Seymour; 69) Petrel; 72) Rud; 75) Western; 77) Eastern; 80) Pervenets; 82) Zhemchug; 84) Pribylov. Troughs: 5) Litke; 12) Olyutorsk; 16) Lower Khatyrka; 20) Lower Anadyr; 24) Krest Bay; 25) Keskureyem volcano-tectonic; 27) Mechigmen; 42) Nushagak; 46) Cook; 51) Shelekhov; 54) Bering; 57) Unalashka; 62) Atka; 67) Seymour; 70) Petrel; 71) Rud; 73) Central; 77) Shirshov; 78) Navarin; 79) Pervenets; 81) Zhemchug; 83) Pribylov. Faults: 29) Kaltag; 34) Inditaod; 32) Aniak; 36) Farewell; 36) Kholitna; 39) Todzhuak; 44) Bruin Bay; 59) Amukhta; 60) Amlya; 64) Adakh; 65) Buldir system.
Buldir system.

Figure 4.

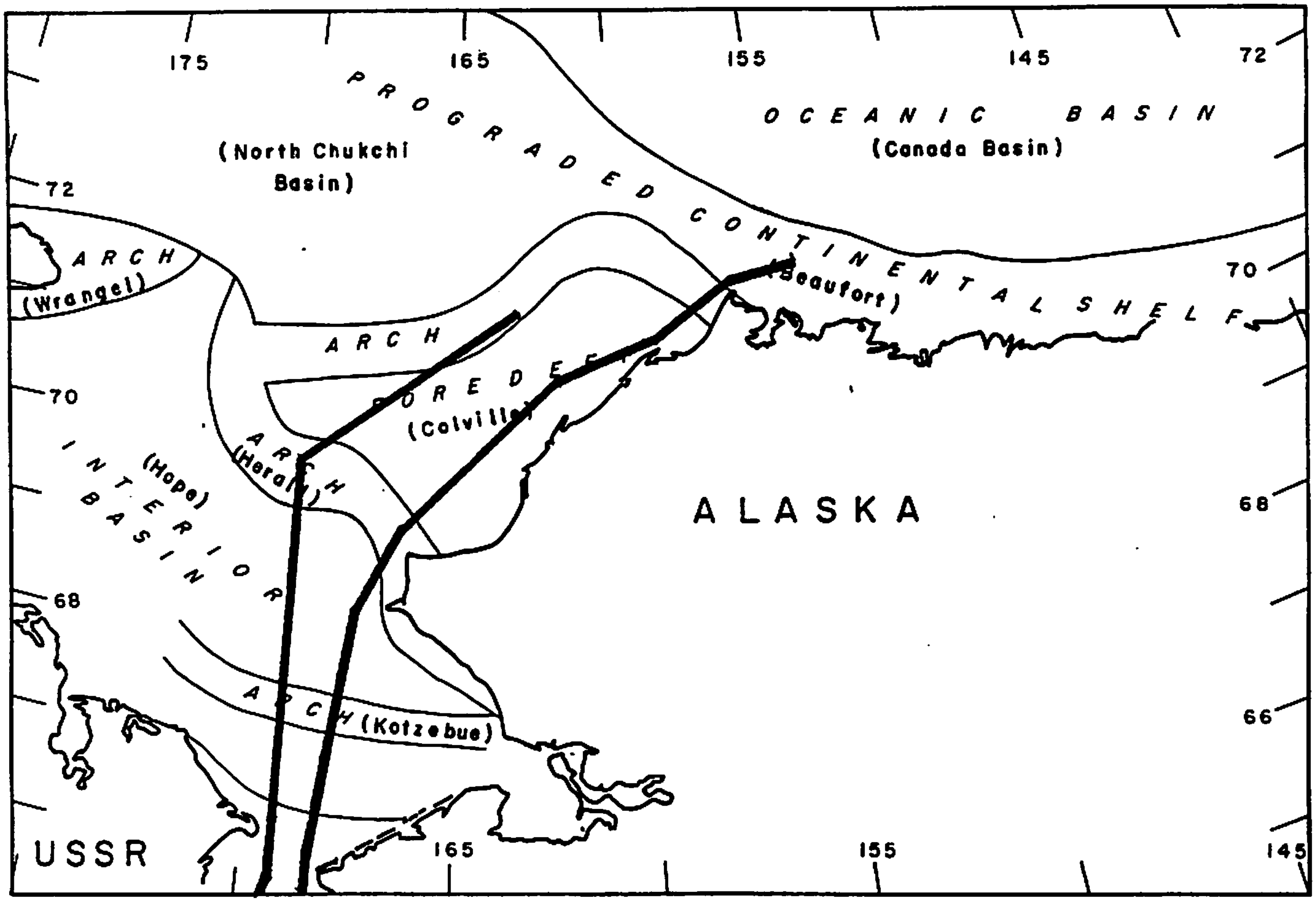

175
165
155
145
72
PROGRADED CONTINENTAL SHELF
OCEANIC BASIN
(Canada Basin)
(North Chukchi Basin)
ARCH
(Wrangel)
ARCH
FOREDEEP
(Colville)
(Beaufort)
ARCH
(Herald)
(Hope)
INTERIOR BASIN
ARCH (Kotzebue)
ALASKA
USSR
70
68
66

Figure 5

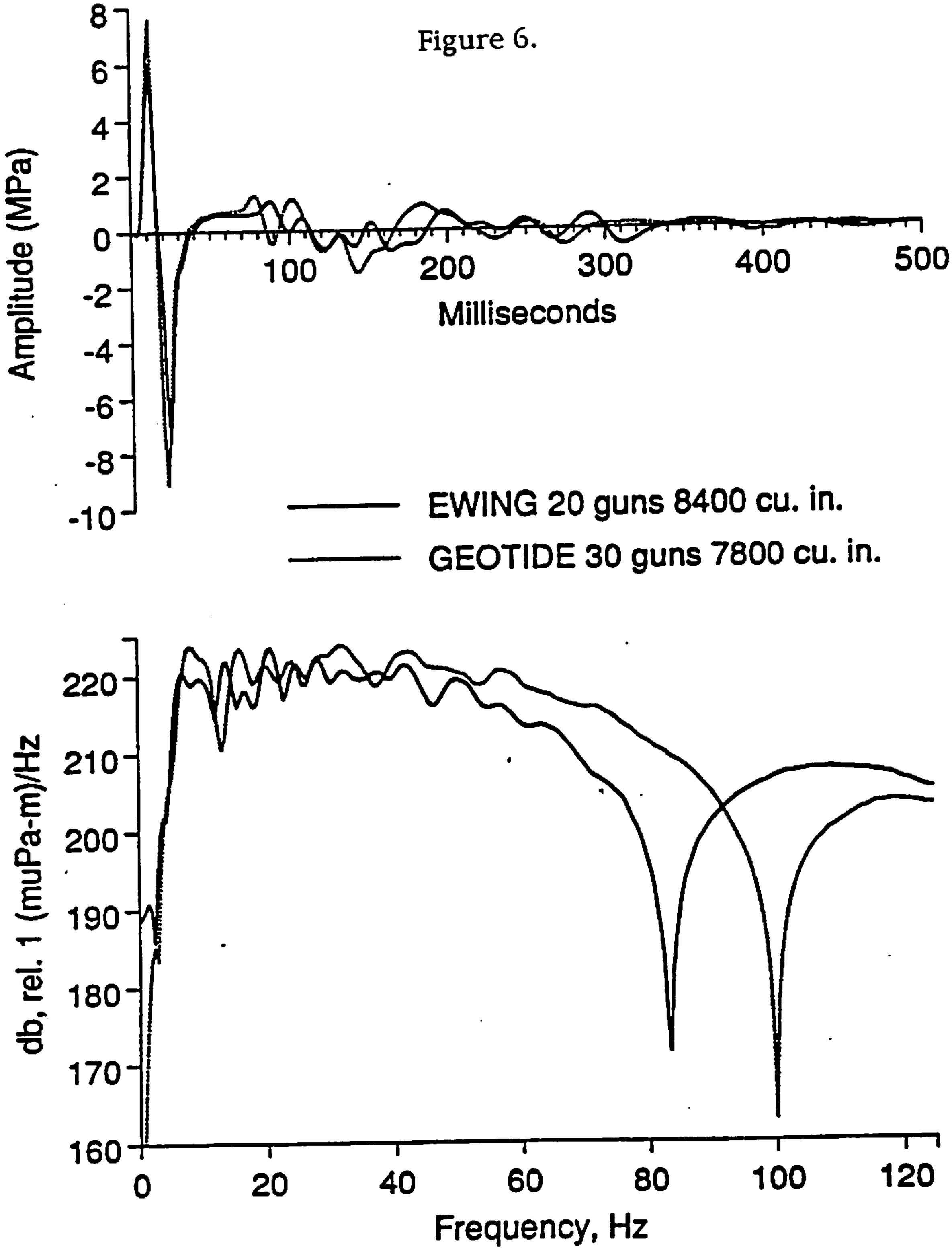
STARBOARD

```
|---------------------------GUN  1------------------------|1 4 5
 |---------------------------GUN  2--------------------------------------|8 5 0
 |---------------------------GUN  3--------------------------------|2 3 5
|---------------------------GUN  4------------------------|3 0 5
 |---------------------------GUN  5--------------------------------------|5 2 0
 |---------------------------GUN  6--------------------------------|3 8 5
|---------------------------GUN  7------------------------|2 5 0
 |---------------------------GUN  8--------------------------------------|8 5 0

 |---------------------------GUN  9--------------------------------|5 4 0
|---------------------------GUN  10-----------------------|1 4 5
|---------------------------GUN  11-----------------------|1 4 5
 |---------------------------GUN  12-------------------------------|5 0 0

 |---------------------------GUN  13-------------------------------------|7 6 0
|---------------------------GUN  14-----------------------|2 5 0
 |---------------------------GUN  15-------------------------------|3 5 0
 |---------------------------GUN  16-------------------------------------|5 2 0
|---------------------------GUN  17-----------------------|3 5 0
 |---------------------------GUN  18-------------------------------|2 6 0
 |---------------------------GUN  19-------------------------------------|8 5 0
 |---------------------------GUN  20-----------------------|145
```

PORT

```
|<------------------------   115  ft   --------------------->|
 |<----------------------------------   130  ft   ---------------------->|
  |<---------------------------------------   145  ft   ----------------------->|
```

Figure 6.


Amplitude (MPa)
8
6
4
2
0
-2
-4
-6
-8
-10
100
200
300
400
500
Milliseconds
EWING 20 guns 8400 cu. in.
GEOTIDE 30 guns 7800 cu. in.
db, rel. 1 (muPa-m)/Hz
220
210
200
190
180
170
160
0
20
40
60
80
100
120
Frequency, Hz

Maurice Ewing, Leg 94-10

Figure 7, 8, and 9 could not be scanned because of irregular size.