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Date: January 21, 1994

To:

Aitken, T.	L-DEO
Chayes, D.	L-DEO
Cox, L.	L-DEO
Eaton, G.	L-DEO
Hayes, D.	L-DEO
Mutter, J.	L-DEO
MARSCICO,	L-DEO
Stennett, J.	L-DEO
Robinson, W.	L-DEO
Science Officer	EWING
Captain	EWING
Chief Engineer	EWING

RESEARCH CRUISE REPORT

R/V MAURICE EWING, LEG 93-09

"Rock Dredging and Geochemical Study of the Mid-Atlantic Ridge from 41°S to 51°S"

P.I. Dr. Jean-Guy Schilling, University of Rhode Island
Dates: 20 November to 27 December 1993
Ports: Cape Town, Union of South Africa to Montevideo, Uruguay

mr/2/93

Mercy Garland
Marine Department

January 21, 1994

Cruise Report
R/V Maurice Ewing
EW9309

Schedule: Left Cape Town, South Africa November 20, 1990.
Dredged the Mid-Atlantic Ridge from 40°S to 52°30'S.
Returned to Montevideo, Uruguay on December 27, 1993.

Inclusive Dates: November 20 - December 27, 1993

Days at Sea: 38

Days in Port: 2

Participating Personnel:

(1) Scientific Party

Schilling, Jean-Guy	Chief Scientist	URI
Kingsley, Richard	Marine Research Specialist	URI
Doulgass, Jill	Graduate Student	URI
Small, Chris	Geophysicist	LDEO
Chen, John	Geophysicist	OSU
Carruthers, Margaret	Graduate Student	Univ. of Mass.
Johannsen, Peter	Geologist	
Fontignie, Denis	Geochemist	Univ. of Geneva
Sarda, Philippe	Geochemist	Univ. of Paris
Moreira, Manuel	Graduate Student	Univ. of Paris
Martinez, Iuma	Graduate Student	Univ. of Cape Town
Spath, Andreas	Graduate Student	Univ. of Cape Town
Stennett, Joe	Science Officer	LDEO
Bissell, Dan	Hydrosweep Technician	LDEO
Robinson, Bill	System Manager	LDEO
Maiwiriwiri, Ropate	Core Bosun	LDEO
Chayes, Dale N.	Hydrosweep Engineer	LDEO
Pitman, R.V.	Electronic Technician	LDEO

(2) Ship's Company

Young, Ian W.	Master	LDEO
Mello, Louis J.	Chief Mate	LDEO
Phillips, David L.	Second Mate	LDEO
Landow, Mark C.	Third Mate	LDEO
Santini, John J.	Boatswain	LDEO
Barros, Larry W.	A/B	LDEO
Golenski, Kenneth D.	A/B	LDEO
Sylvia, Jeffrey	A/B	LDEO
Ureta, Javier A.	O/S	LDEO
Bellanger, Denis	Cook	LDEO
Pica, Stephen M.	Chief Engineer.	LDEO
Tucke, Matthew S.	First Engineer.	LDEO
Walsh, Albert H.	Second Engineer.	LDEO
Van Duyne, Matthew J.	Third Engineer.	LDEO

Christian, Mark R.	Oiler	LDEO
Maker, Greenleaf C.	Oiler	LDEO
Uribe, Guillermo F.	Oiler	LDEO
Newton, Gil E.	Wiper	LDEO
Schwartz, John H.	Electrician	LDEO
Paloney, Frank	Steward	LDEO
Moqo, Luke	Messmen	LDEO
Martin, Pete A.	Radio Op.	LDEO

Project Title: Rock dredging and geochemical study of the Mid-Atlantic Ridge from 41°S to 51°S

Principal Investigator: Jean-Guy Schilling, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, 02882

Funding Agency: National Science Foundation, Division of Oceanography (MG&G)

Grant Number: OCE 90-11741 (3/1/93-8/31/94)

Scientific Purpose: The South Atlantic is apparently the locus of a broad boundary between two major geochemical provinces of the Earth's mantle. The province centered over the Indian Ocean is referred as the DUPAL anomaly. This anomaly may be the result of contamination of the asthenosphere either by delamination of sub-continental lithosphere during the breakup and scatter of Gondawanaland, or from the dispersal of mantle plumes of deeper origin within the Earth.

Specifically, we plan to delineate by geophysical, geochemical and morphotectonic means the possible influence of the so-called Gough, Discovery and Shona hotspots on the MAR between 40°S and 54°S (Fig.1).

Auxiliary Program: Satellite gravity data from the southern Mid-Atlantic Ridge show what appears to be a transition from "slow spreading", axial valley morphology to "fast spreading", axial rise morphology on the ridge segment at 51.5°S. We plan to survey this segment with Hydrosweep bathymetry and gravity in order to map the morphology and determine sub-seafloor density structure. Our objective is to investigate the possibility of variations of either the crustal thickness or the mantle temperature accompanying the change in morphology and gravity. Coincident geophysical and petrologic sampling in this area will provide a multi-disciplinary approach to this problem.

Breakdown of Operations:

	Hours
Transit to and from MAR†	384
Stations (rock dredging)	164
Geophysical survey I*	339
Geophysical survey II†	112

* Includes continuous high resolution bathymetric swath mapping (Hydrosweep), 3.5 and 12khz single channel profiling, and gravity data collection.
† Same as above plus continuous magnetic field intensity recording.

Preliminary Results:

Figure 1 provides the ship tracks followed during the cruise. Hydrosweep mutibeam bathymetric and gravity surveying was continuous along the track, except within 200 miles of the coast of South Africa and Uruguay. The intensity of the magnetic field was also recorded during the survey of the Shona gravity high and during long transits. The location of the 45 dredge sites occupied are shown in relation to the tectonics of the region in Figures 2, and with respect to Sandwell's recent free-air gravity map (Geosat & ERS-1 altimetry) in Figure 3. A preliminary water depth and gravity profile along the Mid-Atlantic Ridge axis from 52.5 °S to 40°S is shown in Figure 4. Table 1 provides the coordinates of the dredge stations and a brief description of the rock types recovered in each of the dredge hauls, including volcanic glass. A 75-inch/degree, 20m contour bathymetric map was prepared for each dredge site showing the feature dredged and the ship track followed during dredging, according to GPS positioning. Figures 6 and 7 are two examples. The other 43 maps are available upon request.

The following operations and tentative observations were made during the cruise:

1) Transit from Cape Town to the MAR 47° 30'S: Our track passed over the Discovery Seamount Chain. We attempted to dredge one of these seamounts but recovered only a large rounded glacial erratic covered with a thick coating of manganese. The rock is a beautiful coarse grain granite probably from Antarctica!

2) MAR 47° 30'S to 52° 30'S: Guided by Sandwell's recent free-air gravity map (Geosat & ERS-1 altimetry) and Hydrosweep, we followed the MAR axis from 47° 30'S to 52° 30'S and occupied 24 dredge stations at 25-30 km intervals. Very fresh to fresh glassy basalts were recovered from 23 of the 24 dredge hauls. Nine of these stations were occupied over the gravity high where the ridge axis also shoals, just south of the Aguhlas FZ (Fig.3). This feature is probably related to the Discovery hot spot though it has a rift valley. Overall, we found Sandwell's gravity map extremely reliable in guiding us along the axis of the MAR.

3) Geophysical survey of the Shona gravity - geochemical anomaly over the MAR axis (50° 30'S - 52° 30'S): A geophysical survey of the Shona gravity - geochemical anomaly centered on the MAR axis (50.5° - 52.5° S) was completed. Fifteen ~100 km, sub-parallel, E/NE oriented survey lines were collected. Additional coverage was provided by nine dredge site surveys and an axial tie line running the length of the survey area. A total of 1780 km of survey resulted in ~40% Hydrosweep coverage of a 47000 km^2 region centered on the rise axis. Marine magnetic anomaly data delineate the approximate location of the rise axis on 13 of the 15 cross axis lines and give a mean full spreading rate of ~32 mm/yr. Near 51° S the magnetic anomalies are more difficult to interpret and indicate some type of complication in the rise axis geometry, possibly a propagating offset. The morphology of the rise axis shows shallow (< 1 km) axial valleys on the ends of the segment which shoal and disappear near the middle of the segment. A well developed axial ridge is not detected anywhere along this segment. A N/S trending basement high is seen on the west side of the rise axis, possibly indicating a northward propagation of some type of ridge axis discontinuity. Over most of the segment the rise flanks show an unusually smooth morphology, almost completely lacking in normal abyssal hills. Near the ends of the segment a more conventional, fast spreading abyssal hill morphology is seen. Coincident gravity and swath bathymetry data will allow mantle Bouguer anomalies to be computed thereby providing constraints on crustal thickness and thermal structure on this ridge segment. Nine dredge stations were also occupied over this feature in order to

delineate more fully the Shona geochemical anomaly first revealed by the limited sampling of le Roex et al 1987.

4) A second complementary Hydrosweep swath over the MAR axis was collected in the return transit from 52.5°S to 47.5°S, where we resumed sampling.

5) The Falkland-Agulhas transform fault was crossed in an east-west fashion at the latitude of 47.37°S. Deeps reaching 5 km were encountered. Notable 1-2 km circular depressions in the sediments were observed on the SE flank of this transform.

6) Six successful dredge stations were occupied along the long north-south MAR segment between 46.1° -47.4°S, just north of the Falkland FZ. The northwest trending MAR axis between 47.4-44.5°S, is characterized at least 4 short, N-NW trending, segments placed en echelon and separated by short non-transform faults. Oblique spreading may be taking place along this part of the MAR. Five successful dredge hauls out of 7 attempts were recovered along this part of the MAR.

Our dredging operation was considerably hampered or prevented by bad weather, very rough seas with winds up to 50 nm/hr. Two dredges were lost due to failure of the hook at the bottom of the 1/2 ton weight placed in front of the dredge. Time was also lost due to the trawl cable jumping off the sheave and loosening of the counterweight on the flag block as a result of the rough sea.

7) Only five successful dredge stations were occupied along the north-south trending MAR between 44.5-40°N, due to continuing bad weather and rough seas. The MAR rift valley floor appears to be characterized by more intense, along-axis, faulting and seems more amagmatic than further south. Highly plagiophyric pillow basalts were consistently recovered from small volcanoes located in central basins of the MAR rift valley floor over this section of the ridge. Mostly passive spreading may characterize this section of the MAR.

Dredging operations ended at 14:00, December 18, 1993, and the 9-day transit to Montevideo begun.

8) *Ridge Segmentation:* During the 21 day survey along the ridge axis, we have attempted to document in a preliminary fashion the ridge segmentation of the southern Mid-Atlantic Ridge (MAR) from 40.5°S to 52.3°S, where the spreading rate is approximately 16 mm/yr (half-rate). Over this region the MAR has a well-defined rift valley, typical of slow spreading ridges, except south of 50.5°S over the so-called Shona anomaly high where it is lacking. The ridge axis is highly segmented, and is generally represented by 20 km to 100 km long segments. This is suggested in Sandwell's satellite gravity map and was essentially confirmed by our reconnaissance Hydrosweep bathymetry data. Along the northwest trending MAR between 47.4°S and 44.5°S, just north of the Falkland FZ, the axis consists of at least 4 short, north trending segments placed en echelon and separated by non-transform offsets. Oblique spreading may be taking place along this part of the MAR. Although most of the offsets along the ridge axis we surveyed take place in a left step fashion, there are at least four right step offsets at about 42.5°S, 43°S, 46.7°S, and 48.4°S, respectively (Fig. 2).

9) *Gravity data:* Gridded satellite gravity data show very good agreement with shipboard gravity data collected by the KSS-30 and BGM-3 gravimeters. Although the satellite gravity data lack the full resolution of the shipboard data, the satellite gravity data

do resolve the larger scale bathymetric features such as seamounts (Fig. 5a), fracture zones and the axial valley on the ridge axis. A spectral analysis of 3250 km of coincident shipboard and satellite gravity and bathymetry data indicates that features as small as ~20 km wavelength are resolved by the satellite gravity data (Fig. 5b).

Post cruise analytical programs:

A collaborative and coordinated petrological, geochemical and isotopic program of study of the rocks recovered, emphasizing glasses, has been established between the cruise's participants from the University of Rhode Island, University of Cape Town, the University of Geneva, and the University of Paris. The geophysical data gathered during the cruise will be reduced and interpreted by Chris Small (LDEO) and John Chen (OSU) and integrated with the geochemical data in collaboration with Jean-Guy Schilling (URI) and coworkers-workers.

Acknowledgments:

The professionalism and dedicated assistance and cooperation of Captain Ian Young and his ship's company, including Chief Engineer Stephen Pica and his staff, Joe Stennet, Science Officer, and Michael Rawson, Science Coordinator, Bill Robinson, Ropate Maiwiriwiri, and Dale Chayes is greatly appreciated. Special thanks go to Chief Mate Louis Mello and Boatswain Santini and their deck crew who braved wet, wind and wave to launch and recover dredging equipment and repair the trawl block high on the stern A-frame over rough seas. We thank Pete Martin whose elegant patch of the weather fax system allowed us to see the low pressure systems coming at least a day ahead of time. The success of this sampling program would not have been possible without the dedication, hard work and perserverance of the scientific party under the difficult conditions present in this part of the ocean. Finally, we thank Steward Frank Paloney, Denis Bellanger, and Luke Moqo whose fine cuisine offered daily respite from strong wind and foul conditions.

Table 1: EW9309 Dredge Haul Recovery

Station ID #	Latitude Longitude	Depth (meters)	Feature Dredged	Date	Rock Recovery	Glass Recovery	Weight (kg)
1D	45°08'S 4°24.5'W	2782-2492	Seamount, SW end of Discovery Chain	11/26/93	Glacial erratics and Manganese crust	None	18
2D	47°32.9'S 10°11.1'W	2552-2435	Small volcano - center of MAR rift valley floor - over Discovery gravity high	11/27/93	1) Pillow basalt fragments - one large with thick glassy crust 2) Very fresh glassy slabs	Abundant	247
3D	47°47.7'S 10°09.2'W	2654-2444	Center of MAR rift valley floor - over Discovery gravity high	11/28/93	1) Pillow basalt fragments with variable amount of glass, Mn-coating and hydrothermal stains - 2-3 types probably 2) Small rounded serpentinite cobble	Few nuggets	441
4D	47°58'S 10°05'W	2990-2800	East flank of volcanic ridge - center of MAR rift valley floor - over Discovery gravity high	11/28/93	Very fresh glassy pillow basalts with abundant glass and crust	Abundant	182
5D	48°14.4'S 9°59.7'W	3525-3380	Volcanic ridge - center of MAR rift valley floor - over Discovery gravity high	11/28/93	Pillow basalt fragments with minor glass retained	Minor chips	272
6D	48°33.21'S 10°10.0'W	3279-3255	Center of MAR rift valley floor - over Discovery gravity high	11/28/93	One pillow basalt fragment with some glass retained	Minor chips	25
7D	48°45.6'S 10°04.2W	3272-3163	Deep - MAR rift valley floor	11/29/93	1) Aphyric pillow basalt with some glass retained 2) Highly plagiophyric pillow basalt with glassy crust 3) Fresh highly plagiophyric pillow basalt with	Fresh station glass Abundant aphyric glass nuggets One popped	250
8D	48°57.8'S 9°58.4W	3911-3876	Elongated volcano - center of MAR rift valley floor - south end of Discovery gravity high	11/29/93	One small pillow basalt with minor glass retained	Poor-variolitic type	20
9D	49°8.8'S 9°54.6'W	4004-3780	Two small hills in center of MAR rift valley floor - south end of Discovery gravity high	11/29/93	Three types of basalts: 1) Extremely fresh, highly glassy slabs 2) Pillow fragments with some glass retained	Abundant nuggets	150
10D	49°14.7S 8°8.4'W	3970-3750	MAR valley floor - Nodal deep at RTI	11/30/93	Two types of pillow basalts: 1) Plagiophyric pillow basalts with some glass retained (tallus - older type) 2) Fresh, glassy, plagiophyric basalt from deep basin	Few nuggets	241
11D	49°26.6'S 7°58.0'W	3884-3852	Center of MAR rift valley floor	11/30/93	Pillow and slabs of basalt with glass	Abundant glass nuggets	255
12D	49°45.4'S 8°2.0'W	3951-3797	Two small hills in center of MAR rift valley floor	11/30/93	Plagiophyric basalt with glassy, striated crust	Abundant nuggets and chips - granular	250

Table 1: EW9309 Dredge Haul Recovery

Station ID #	Latitude Longitude	Depth (meters)	Feature Dredged	Date	Rock Recovery	Glass Recovery	Weight (kg)
13D	49°59.6'S 7°52.9'W	3646-3464	Small volcano in center of MAR rift valley floor	12/1/93	Fresh, glassy pillow and slab basalts, and a few aa type pieces	Abundant nuggets	218
14D	50°16.0'S 7°3.7'W	3387-3307	Volcanic ridge in center of MAR rift valley floor	12/1/93	Pillow basalt with some glass and glassy crust retained with manganese coating	Minor chips	222
15D	50°34.7'S 6°25.7'W	3021-2939	Center of MAR rift valley floor - north part of Shona gravity high	12/1/93	1) Very fresh and glassy pillow and slab basalt - some hydrothermal stains 2) One older pillow with some glass	Abundant nuggets	227
16D	50°49.8'S 6°25.7'W	2874-2863	Basin on flank of MAR axis	12/2/93	None		
17D	50°45.4'S 6°20.2'W	3050-2835	Small volcano in center of MAR rift valley floor - north transition zone of Shona gravity high	12/3/93	Pillow basalt with some glass retained and thin manganese coating; traces of glob ooze	Few nuggets	181
18D	51°03.2'S 6°11.9'W	2029-1953	Elevated ridge axis over Shona gravity high (saddle point) - over axi-symmetric magnetic anomaly	12/4/93	Pillow and slab basalt with some glass retained and thin Mn-coating; glacial erratics and pebbles	Minor	136
19D	51°3.7'S 6°9.5'W	1800-1686	Elevated ridge axis over Shona gravity high - east flank of	12/4/93	Pillow basalt, highly vesicular with some glass retained and with thin Mn-coating; glacial	Few glass fingers	227
20D	51°25.7'S 5°46.8'W	1739-1699	Elevated MAR axis over Shona gravity high - axial part	12/5/93	Two types of pillow and slab basalts: 1) Very fresh glassy crust (dark brown) 2) Older, with some light brown glassy crust	Few nuggets	45
21D	51°49.3'S 5°30.2'W	2070-1980	MAR elevated ridge axis - southern part of Shona gravity high	12/6/93	Highly plagiophyric basalt with minor brown glassy crust	Minor brown crust	227
22D	52°27.5'S 4°34.0'W	3222-2896	Center of MAR rift valley floor - south of Shona gravity high	12/7/93	Very fresh highly glassy slab and pillow basalt - possibly one older type	Abundant nuggets	32
23D	52°9.4'S 5°20.4'W	2664-2554	Small hill in MAR rift valley floor - southern part of Shona gravity high	12/7/93	Very fresh, highly glassy basalt slabs with dark brown crust One large pillow with very fresh glass	Abundant	20
24D	50°27.5'S 6°32.0'W	3378-2988	MAR rift valley floor - northern rifted part of Shona gravity high	12/8/93	1) Small, fist size plagiophyric basalt with fresh glass 2) Small very fresh glassy crust slabs (dark brown)	Limited	0.5
25D	47°20.9'S 10°19.2'W	2087-1977	Volcano in center of MAR rift valley floor - north end of Discovery gravity high	12/10/93	Small pillow fragments with very fresh and thick glass	Abundant large nuggets	23
26D	47°21.2'S 13°23.9'W	3914-3800	MAR-Falkland RTI - central ridge in nodal deep	12/10/93	A few pillow basalt fragments with some glass retained	One nugget	27
27D	47°6.4'S 13°23.9'W	3163-2998	Small volcano in center of MAR rift valley floor	12/11/93	Highly plagiophyric pillow basalt with fresh glassy crust (dark brown)	Minor	136

Table 1: EW9309 Dredge Haul Recovery

Station ID #	Latitude Longitude	Depth (meters)	Feature Dredged	Date	Rock Recovery	Glass Recovery	Weight (kg)
28D	46°54.0'S 13°27.2'W	3433-3400	Small volcano in center of MAR rift valley floor	12/11/93	1) Very fresh plagiophyric pillow and slab basalts with glass striated crust 2) A few aphyric pillow basalt fragments	Abundant plagiophyric nuggets	196
29D	46°39.9'S 13°25.6'W	3860-3850	Deep basin in MAR rift valley floor	12/11/93	Empty dredge		
30D	46°35.5'S 13°23.1'W	3211-3095	Small ridge in center of MAR rift valley floor	12/11/93	Possibly three types of pillow basalts: 1) plagiophyric basalts with fresh, granular glassy crust 2) Older aphyric basalt with some glass retained 3) Small slabs withveryfresh glassy crust (dark brown)	Minor	113
31D	46°23.3'S 13°27.3'W	2852-2792	Small volcano in center of MAR rift valley floor	12/12/93	Two pillow basalts with some glass retained	Poor	5
32D	46°13.8'S 13°33.3'W	3121-3095	Small ridge in MAR rift valley floor at RTI (small transform)	12/12/93	Possibly 4 types of pillow basalts: 1) Highly plagiophyric with some glassy crust retained 2) Small slabs 3) Fist size fresh plagiophyric basalt 4) Older slabs with glass and palagonite	Few nuggets	136
33D	45°59.4'S 14°4.6'W	3550-3212	Volcanic ridge in MAR rift valley floor (20km long segment) (oblique section north of Discovery anomaly)	12/13/93	1) Aphyric basalt with fresh glass (mostly peeled off) 2) Abundant glass nuggets (probably from type 1) with variolitic zone attached 3) Pure glass nuggets 4) Serpentinite pebbles	Abundant nuggets	154
34D	45°50.8'S 14°11.6'W	3501-3384	Small volcanic ridge in MAR rift valley floor (short 20km long segment) (oblique section north of Discovery anomaly)	12/13/93	Fresh glassy pillow basalt fragments - possibly two generations; traces of ooze	Few nuggets	100
35D	45°44.3'S 14°37.3'W	2842-2640	Steep sided ridge in MAR rift valley floor	12/14/93	Dredge lost due to bomb hook failure		
36D	45°34.0'S 14°42.6'W	3229-3000	Small volcano in center of MAR rift valley floor (short 25km long segment) (oblique section north of Discovery anomaly)	12/14/93	Small pieces of pillow basalts with fresh glass (thin)	Limited, but fresh	5
37D	45°14.0'S 15°4.5'W	3668-3400	Small ridge in MAR rift valley floor (oblique section north of Discovery anomaly)	12/15/93	Possibly 3-4 types of pillow and slab basalts ranging from fresh and glassy to glassy with Mn-stains	Minor	91

Table 1: EW9309 Dredge Haul Recovery

Station ID #	Latitude Longitude	Depth (meters)	Feature Dredged	Date	Rock Recovery	Glass Recovery	Weight (kg)
38D	44°48.6'S 15°21.9'W	3860-3639	Deep basin in MAR rift vally floor (short segment)	12/15/93	Dredge lost due to bomb hook failure		
39D	44°40.9'S 15°23.4'W	3685-3520	Small volcano in MAR rift valley floor (northern most station in oblique part of MAR north of Discovery anomaly)	12/15/93	One small pillow basalt fragment Fist size glass piece coated with manganese Glacial erratic pebbles	Minor	1
40D	44°24.6'S 15°54.5'W	3600-3376	Small volcanic ridge in center of MAR rift valley floor	12/16/93	2-3 types of fresh pillow basalt with glass ranging from aphyric to plagiophyric	Abundant nuggets and chips	155
41D	44°1.2'S 16°4.6'W	3600-3444	MAR rift valley floor (small ridge east side)	12/16/93	Large amount of pillow basalt fragments ranging from very fresh and glassy (most abundant) to older looking with Mn-stains and minor glass (possibly 4 types)	Few nuggets	273
42D	43°25.6'S 16°10.1'W	3522-3375	Small volcano in center of MAR rift valley floor	12/16/93	One small chip of glass with brown crust and Mn-coat	Limited	0.5
43D	42°11.1'S 16°4.9'W	3000-2850	Small volcano in center of MAR rift valley floor	12/17/93	Fresh, plagiophyric basalts with glassy crust (dark brown)	Limited	68
44D	40°51.7'S 16°47.5'W	3194-2939	Small volcano in center of MAR rift valley floor	12/17/93	Large haul of plagiophyric pillow basalts - possibly two generations 1) Large pillow with glassy brown crust and Mn stains 2) Small loaf like pillow basalt with thick glass with dark brown crust - very fresh	Few nuggets	259
45D	40°35.2'S 16°46.3'W	3233-3172	Small volcano in deep basin at center of MAR rift valley floor	12/18/93	Highly plagiophyric pillow basalts with fresh, but thin, glassy crust (striated)	Minor	145

Total Weight: 5774

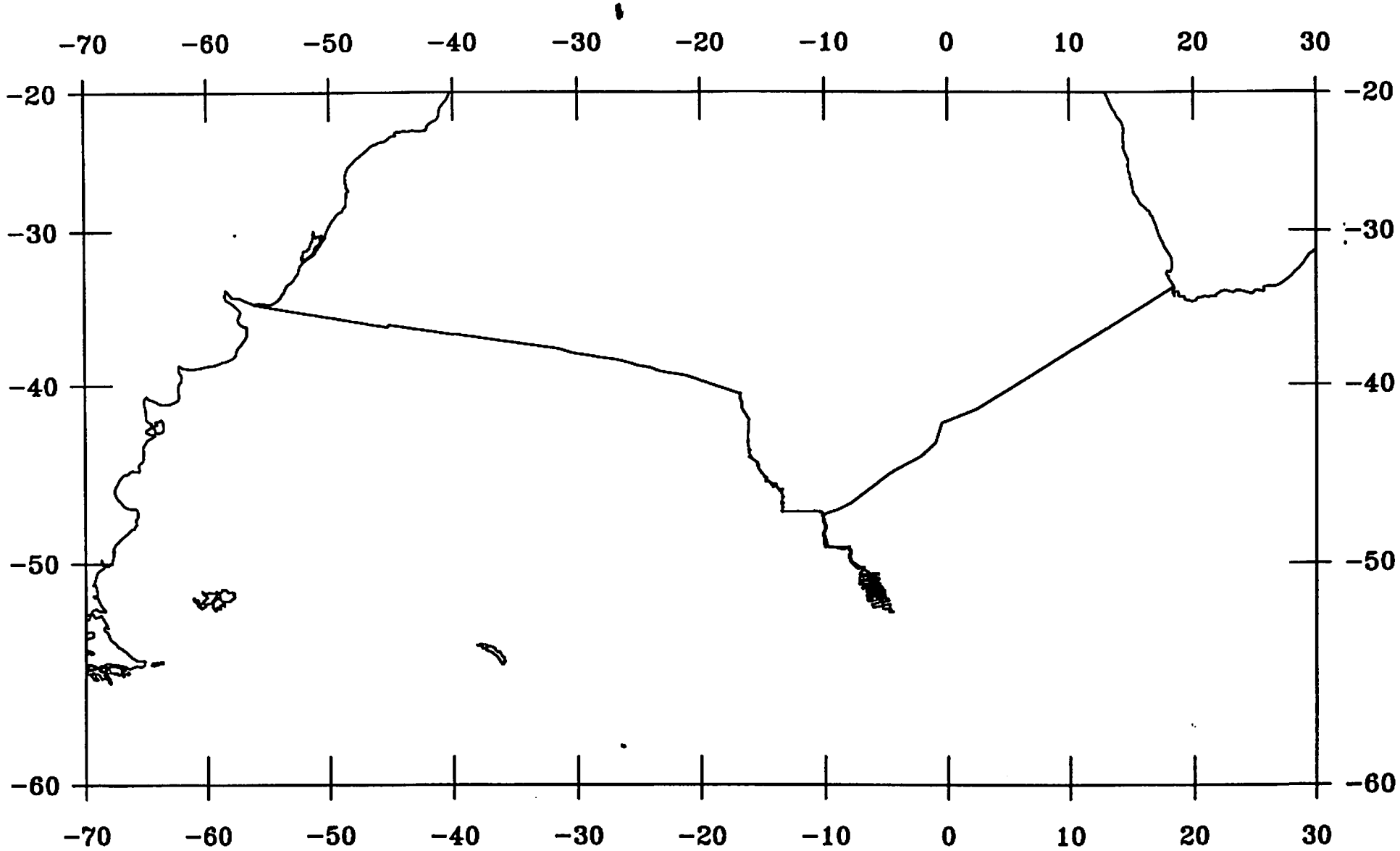

Figure 1 – EW9309 ship track

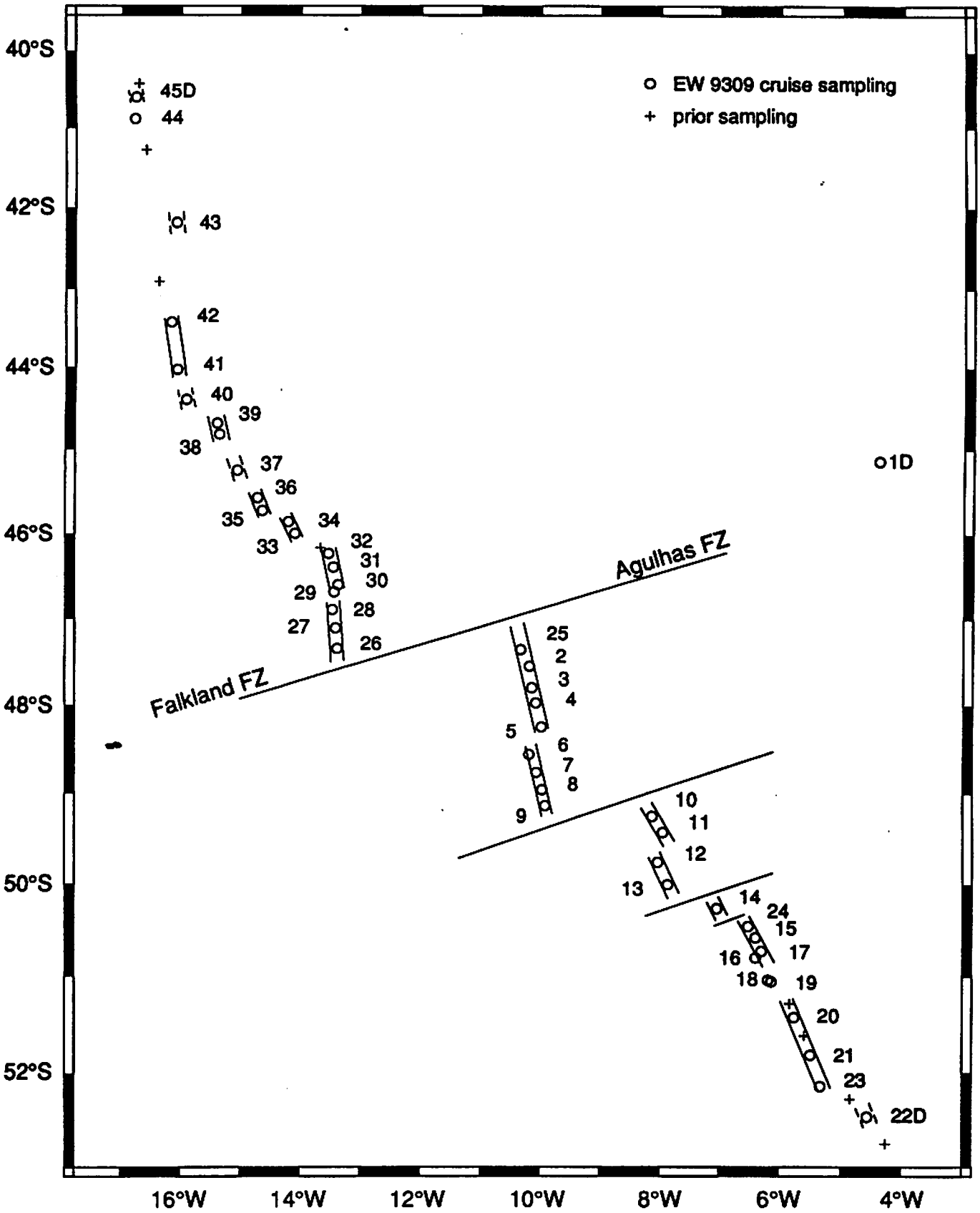

Fig. 2. Dredge station location with schematic ridge axis trend and segmentation based on dredge stations only.

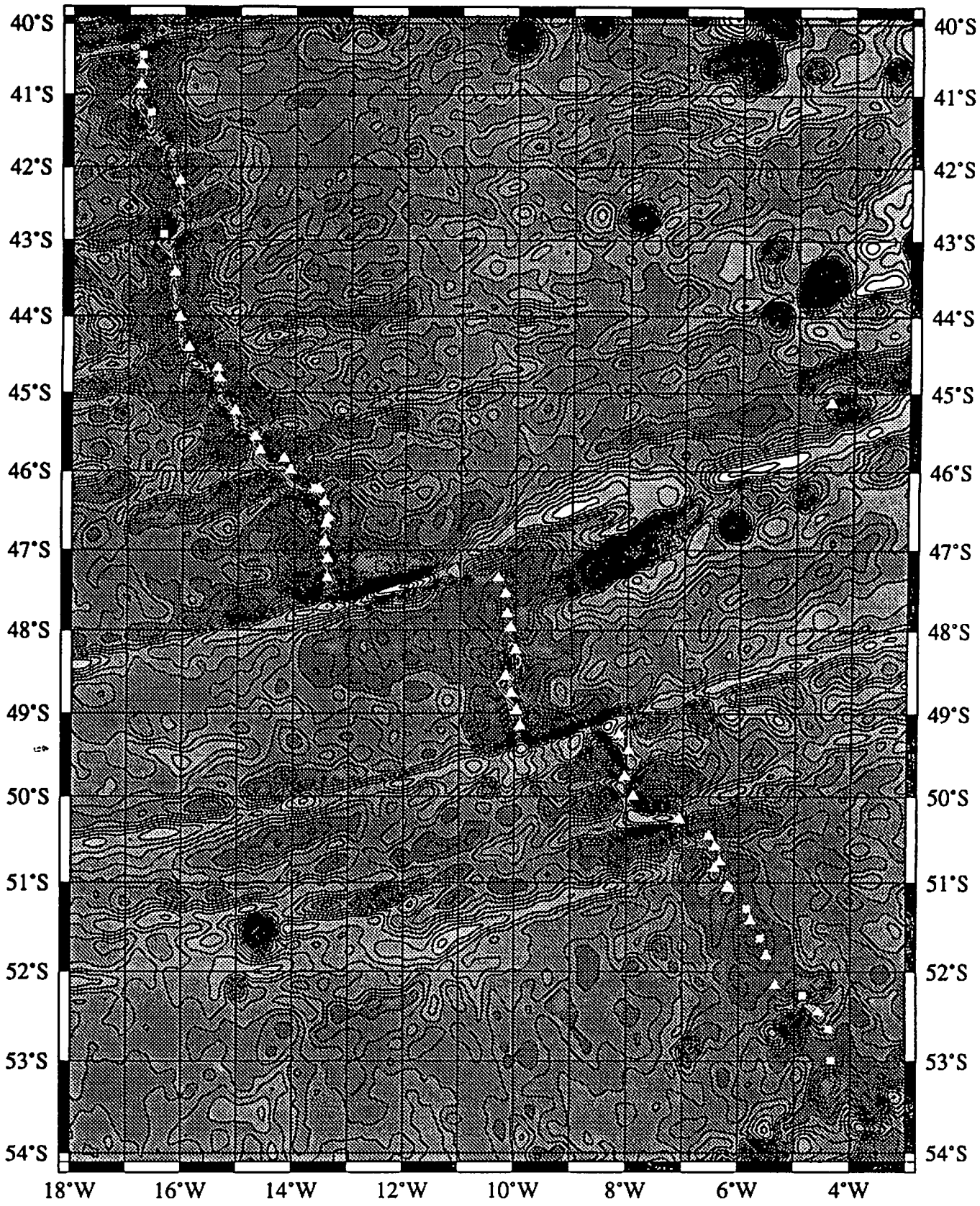

Figure 3. Index map of study area. Dredge stations indicated by triangles, previous sample sites shown by squares. Satellite gravity anomalies shown by shading & contours. Dark regions indicate gravity highs.

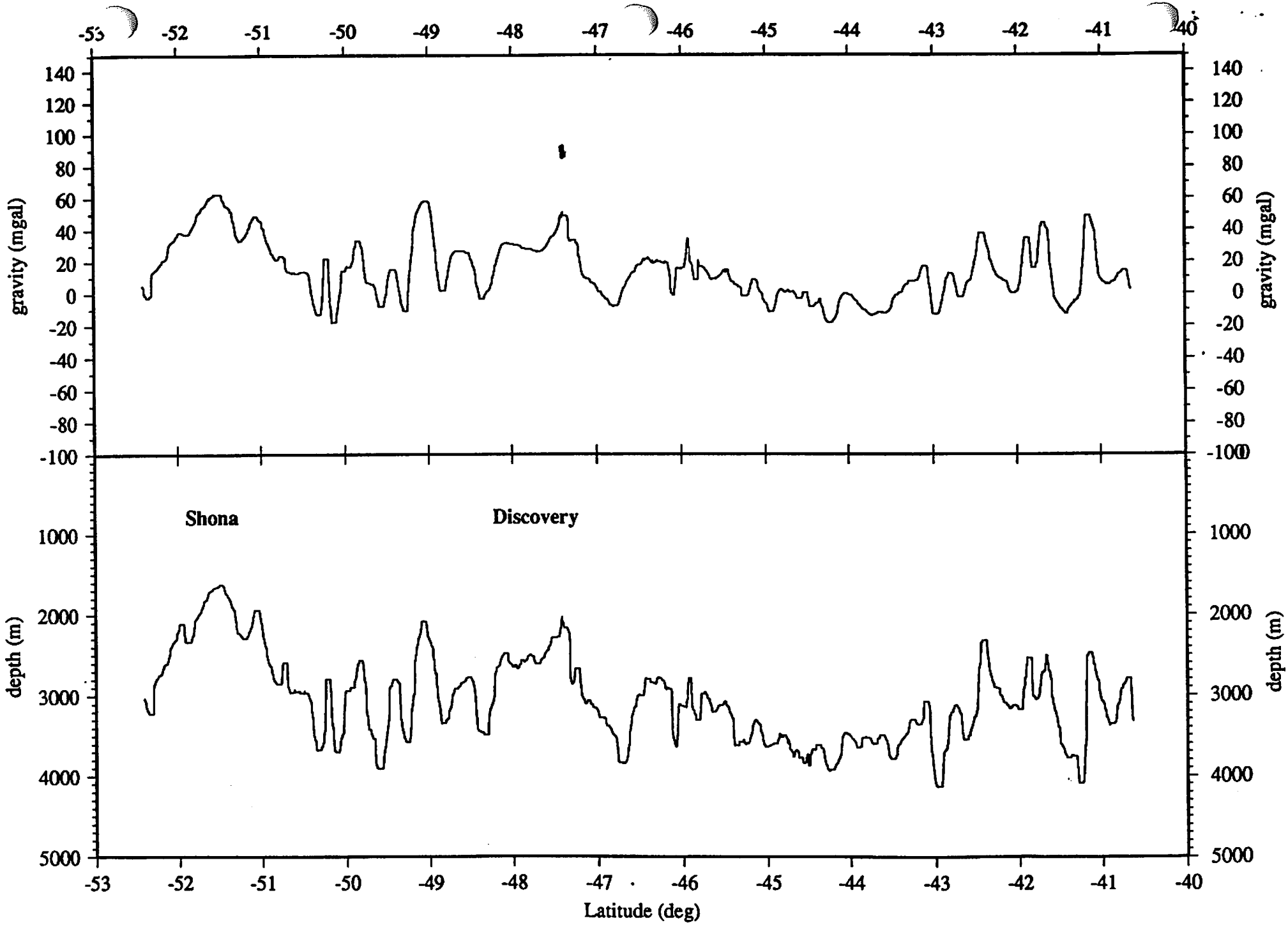

Figure 4. Smoothed water depth and gravity profile along the Mid-Atlantic Ridge track followed during EW93-09. (10 km weighted average of Hydrosweep center beam and BGM-3 free air anomalies)

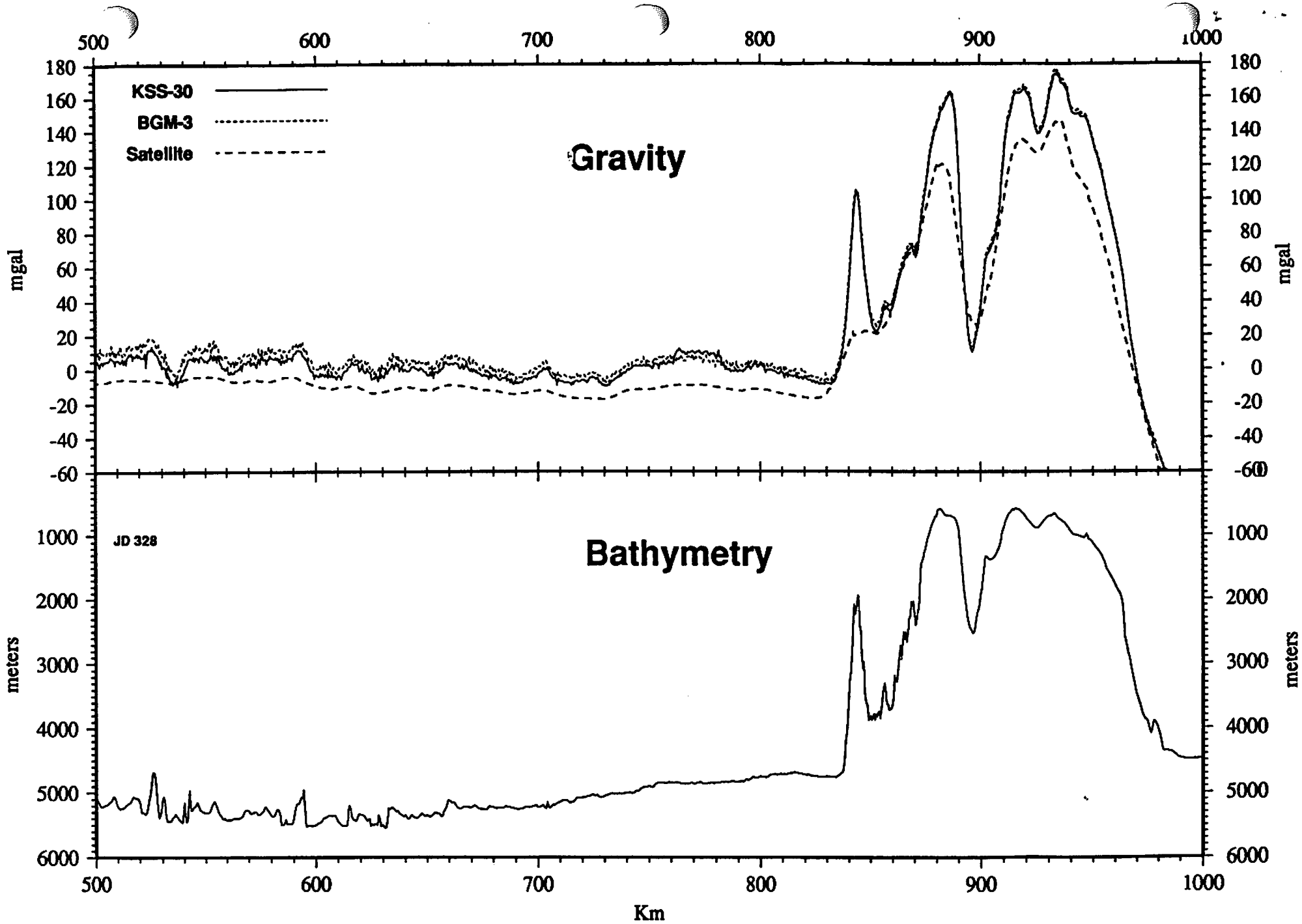

Figure 5a. Comparison of coincident gravity and bathymetry data near the Discovery Seamounts. Note limited resolution but otherwise good agreement between satellite and shipboard gravity for most bathymetric features.

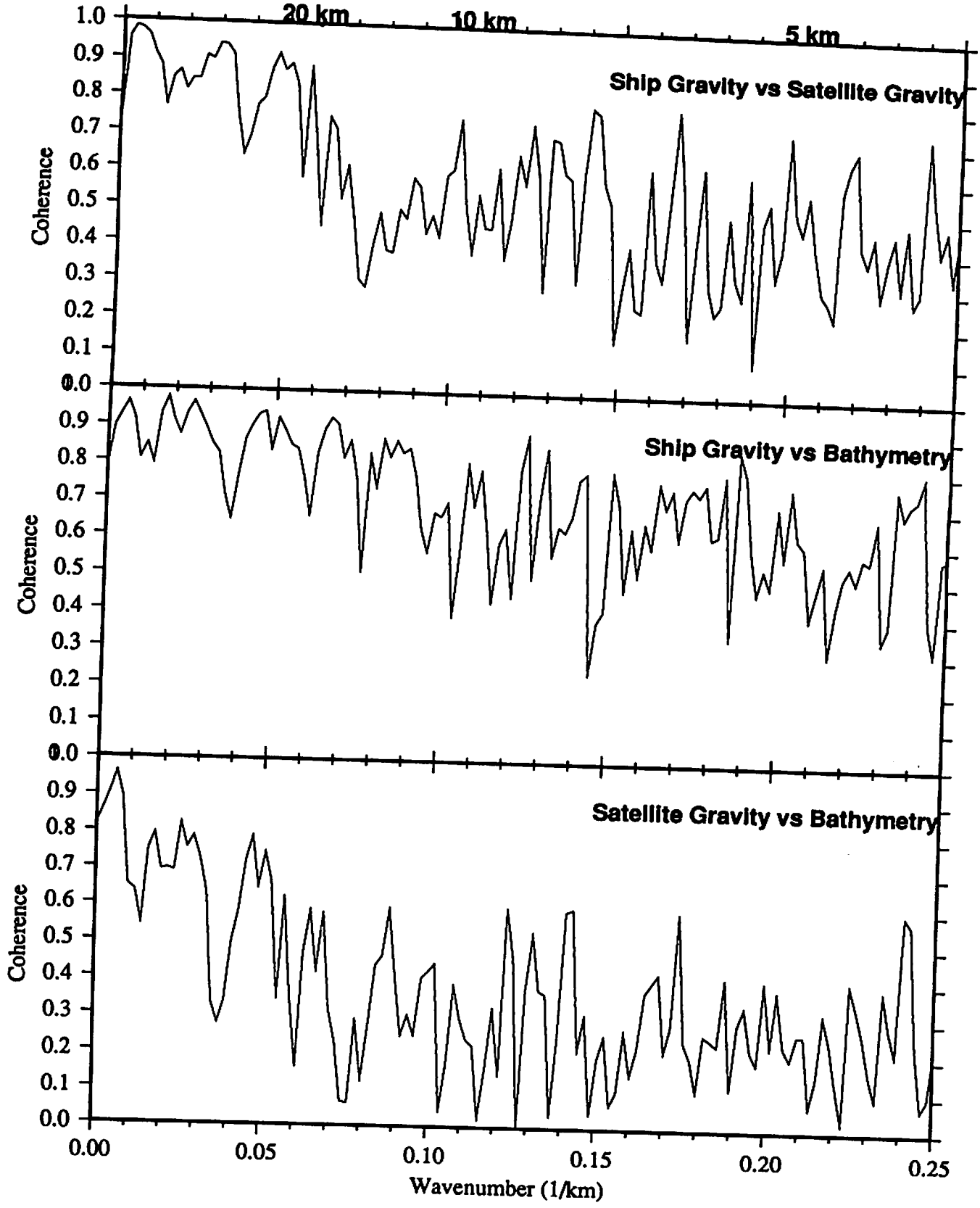

Figure 5b. Spectral coherence as function of wavenumber for 3250 km of coincident gravity & bathymetry data. Coherence of 1 indicates perfect agreement, 0 indicates no agreement.

EW9309 Station 28D

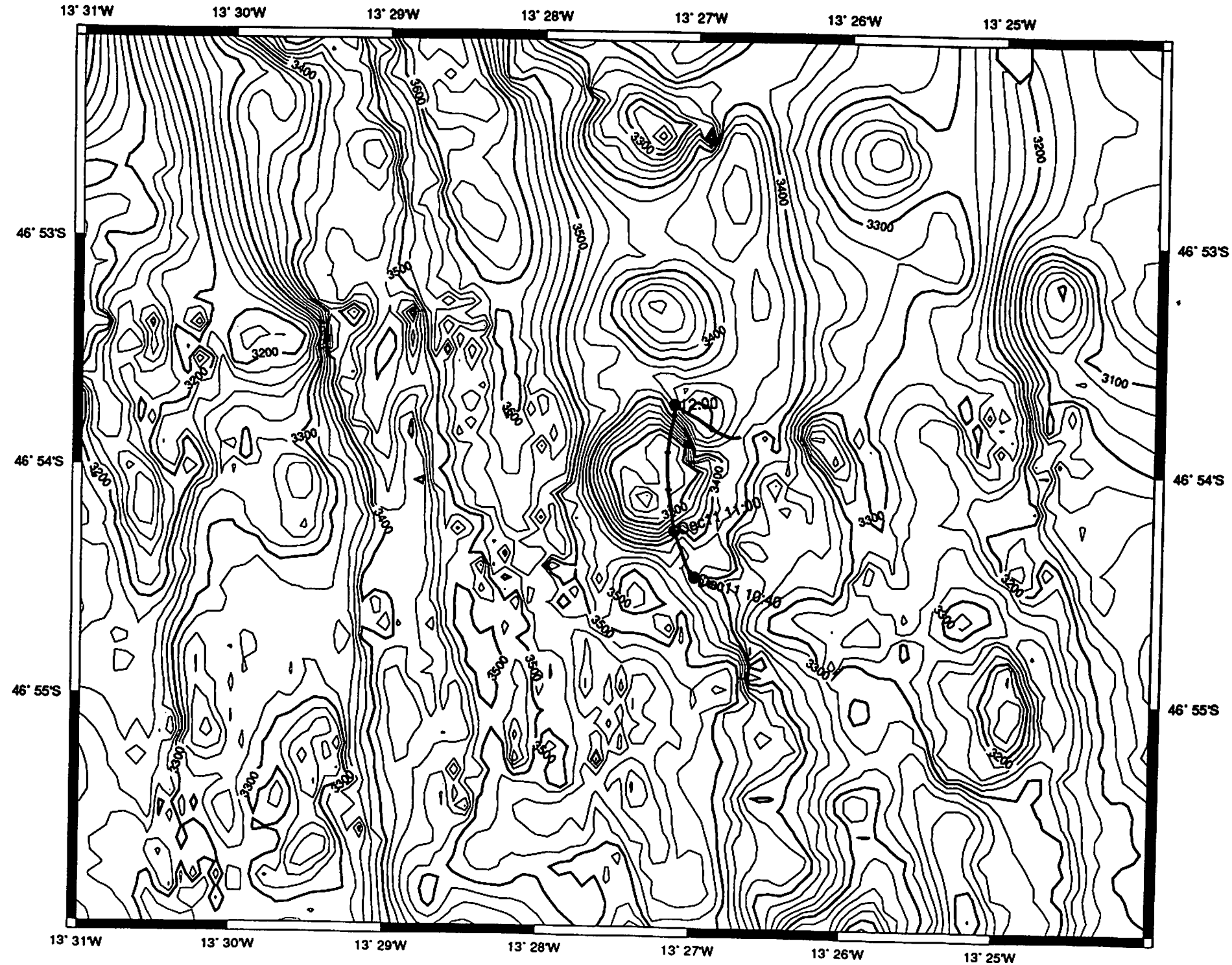

Figure 6

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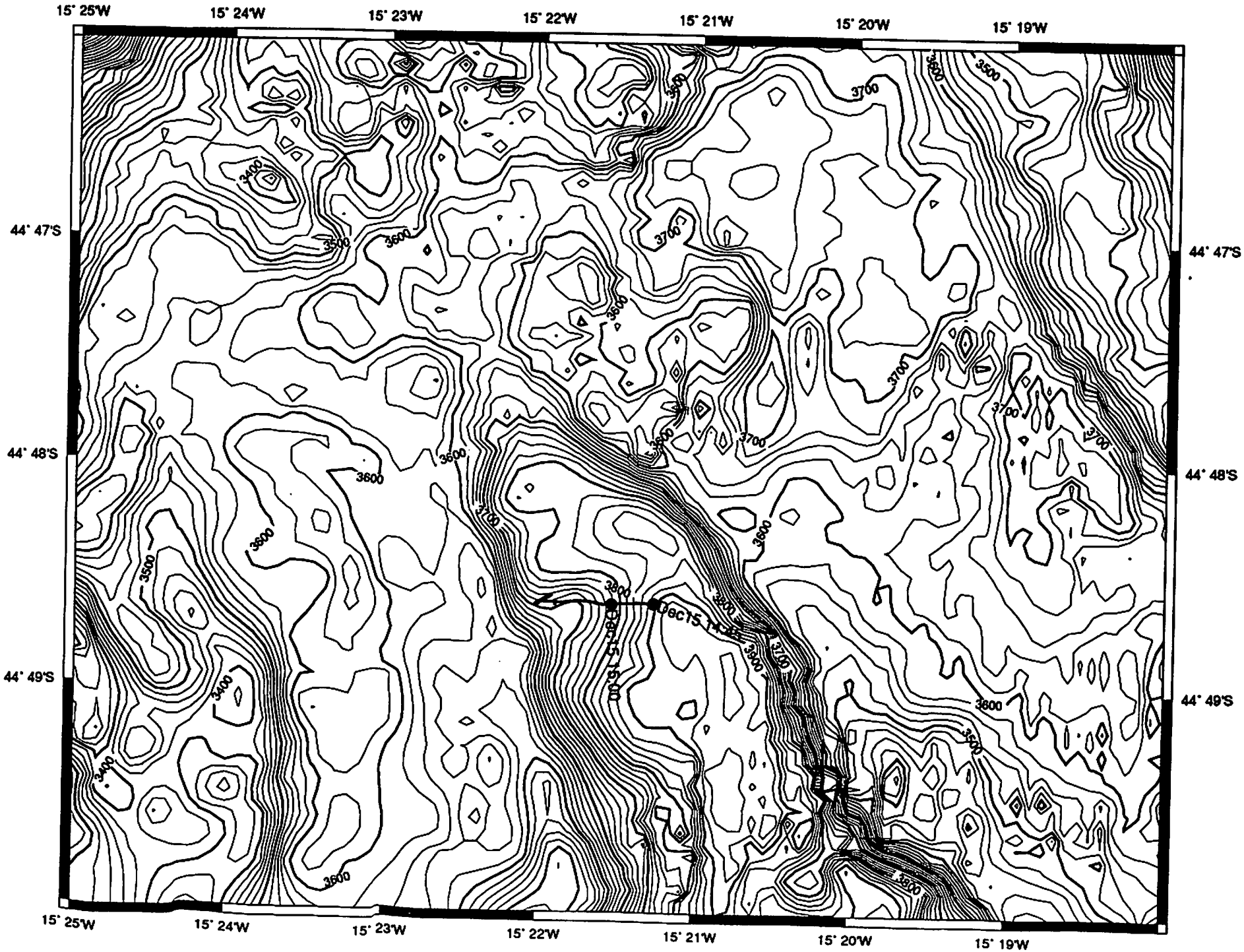

Figure 7