Utilization 91-05

CRUISE REPORT

UNOLS 12/89

Ship Utilization Data

1. Ship Name	2. Operating Institution	3. Cruise (leg) Number
R/V MAURICE EWING	Lamont-Doherty Geological Observatory Palisades, N.Y. 10964	EW91-05

4. Dates of Project:
Begin: 7/29/91
End: 9/20/91

Port Calls

Place	Date
Valparaiso	7/29-7/31
Easter Is.	9/19-9/20

5. Number, Sea Days	6. Number, Port Days
49	5

8a. Area of Operations, Area Index and Geographic Description
East Pacific Rise & Wilkes Transform 7-10d. S.
SE Pacific: SP3

8b. Research in Foreign Waters? _No_

Country: N/A

7. Participating Personnel:

Code Title, Name, Institution	Function on Cruise (Ch.Sci., Obs., Tech., Grad. Student, Undergrad, For.Obsv.)	Dates (If less than entire cruise)
1. Cochran, James, PhD.	Ch. Scientist	
2. Malinverno, Alberto, PhD	Scientist	
3. Yu, Jin, Mr.	Graduate Student	
4. Keely, Christopher, Mr.	Graduate Student	
5. Wang, Xuejin, Mr.	Graduate Student	
6. Webb, Helen, Miss	Graduate Student	
7. Stennett, Joseph, Mr.	Science Officer	
8. O'Hara, Suzanne, Miss	Computer Technician	
9. Halter, Eric, Mr.	Hydrosweep Technician	
10. DePietro, Roger, Mr.	Electronics Technician	
11. Alvarez, Carlos, Mr.	Technician	
12		
13		
14		

Use reverse of necessary

9. Primary Project(s)

a. Project Title, Principal Investigator, Institution	b. Sponsoring Agency/	c. Grant or Contract	d. Participating Personnel	e. Discipline
A Three-Dimensional Study of Isostacy and Morphology at a Super-fast Mid-Ocean Ridgecrest and Flank along a Transform: Dr. James Cochran, L-DGO, PI	NSF (47 Days)	OCE89-11376	Fornari, Dan; L-DGO	MG&G MG&G

10. Ancillary Project(s)

a. Project Title, Principal Investigator, Institution	b. Sponsoring Agency/	c. Grant or Contract	d. Participating Personnel	e. Discipline
Stochlastic Analysis of Abyssal Hill Morphology Adjacent to East Pacific Rise, J. Goff: WHOI	NSF (2 Days)	OCE90-19741	Cochran, J.; L-DGO	MG&G

11. Science Party:

Scientists__2__ Grad. Students__4__

Undergrads__0__ Technicians__5___

Observers__0__

Foreign Observers_____

12. Cost Allocation Data

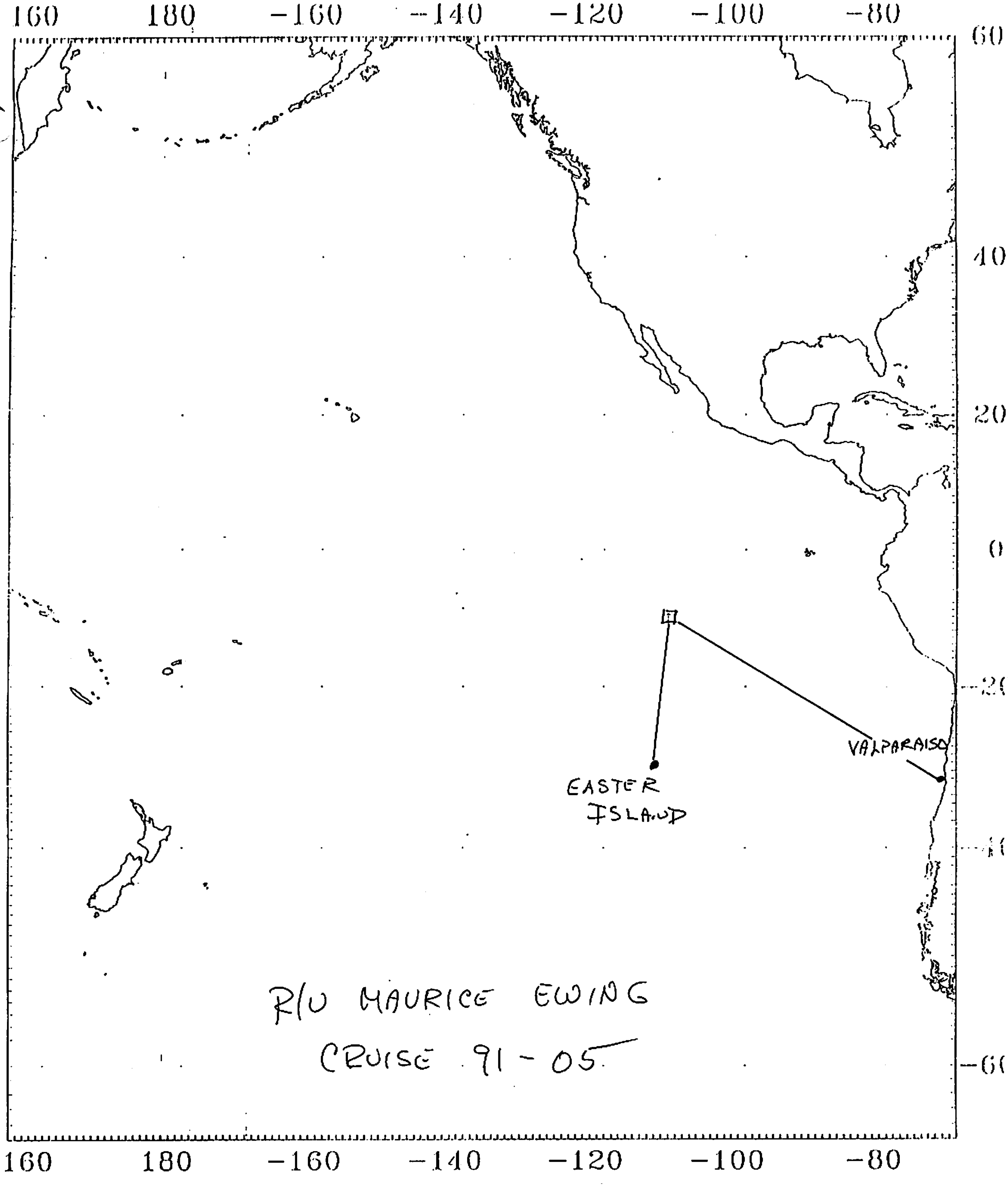
a. Days Charged	b. Agency or Activity Charged	c. Grant or Contract No.
54	NSF	OCE90-01169PR

13

Michael Rawson, Marine Science Coordinator; L-DGO
Title, Signature, Operating Institution Official

Date: March 4, 1992

3/4/92


160
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-60
EASTER ISLAND
VALPARAISO
R/V MAURICE EWING
CRUISE 91-05

TO:	Aitken, T.	LDGO
	Chayes, D.	LDGO
	Cox, L.	LDGO
	Eaton, G.	LDGO
	Hayes, D.	LDGO
	Weissel, J.	LDGO
	Science Officer	EWING
	Captain	EWING
	File Copy	MARSCICO

RESEARCH CRUISE REPORT

R/V MAURICE EWING, Leg 91-05

"East Pacific Rise and Wilkes Transform 7°S-10°S"

P.I.: James Cochran
Dates: August 1, 1991 to September 18, 1991
Ports: Valparaiso to Easter Island

Marine Office

CRUISE REPORT
EW-9105

Dates: August 1, 1991 - September 18, 1991
Ports: Valparaiso, Chile - Easter Island
Area of Survey: East Pacific Rise and Wilkes Transform - 7°S-10°S, 107°W-110°W

Scientific Personnel:

James R. Cochran	Chief Scientist	L-DGO
Alberto Malinverno	Scientist	L-DGO
Yu Jin	Graduate Student	L-DGO
Christopher Keeley	Graduate Student	L-DGO
Xuejin Wang	Graduate Student	L-DGO
Helen Webb	Graduate Student	MIT
Joseph Stennett	Science Officer	L-DGO
Suzanne O'Hara	Computer	L-DGO
Eric Halter	Hydrosweep Computer	URI
Roger DePietro	E.T.	L-DGO
Carlos Alverez	E.T.	L-DGO

Introduction:

The purpose of the field program carried out on R/V Maurice Ewing cruise EW9105 was to conduct a detailed bathymetric and gravity survey of a section of the "superfast" southern East Pacific Rise between roughly 7°S and 9°S and of the 150 km offset Wilkes transform which bounds that ridge segment. to the south. The objectives of the survey, as outlined in the original proposal, were to investigate:

1) the relationship between anomalous gravity and anomalous bathymetry (not explained by a cooling plate model) along the ridge crest, and the manner in which these parameters and their variation along the ridge axis are related to the mass and temperature distribution and to dynamic processes under the axis.

2) changes in the isostatic mechanism with distance from the ridge axis.

3) distribution and size characteristics of abyssal hills and off-axis volcanic features.

4) characteristics of a fast-slipping transform fault.

The project was conceived when it appeared that Ewing would be equiped with a Seabeam system and thus was originally more restricted in scope than the program actually carried out utilizing Hydrosweep. The original plan had been to extend the survey only as far north as 7° 40' S with total Seabeam coverage from 110 km west of the EPR axis to 40 km east of the axis and partial (25%) coverage to 110 km east of the axis. The availability of the Hydrosweep system allowed us to modify the survey by extending total bathymetric coverage to 110 km on each side of the axis and by extending the survey north of the 7°12'S overlapping spreading center (OSC). The revised plan gave complete coverage of an entire major ridge segment from the axis out to crust with an age of 1.6 Ma on both flanks. The survey of the transform remained as in the original plan except that the line spacing was adjusted to the Hydrosweep swathwidth.

An additional related project developed by Dr. John Goff of W.HO.I. was added to the original plan. This involved collecting swath-bathymetry data along two long (~375 km) lines along flow lines extending west from the main survey area to the Anti-Bauer scarp, which marks the western boundary of crust created at the present EPR axis. One line was located in the center of the ridge segment and the second near its southern end, just to the north of the transform. The purpose of the Goff study is to investigate along-ridge variations in the ridge crest processes which form abyssal hills and to investigate off-axis time dependent modifiers to abyssal hill morphology, including sedimentation, mass wasting and off-axis volcanism.

Narrative

The cruise departed from Valparaiso, Chile at 2000 local time on the evening of August 1, 1991. The ship could have sailed considerably earlier in the day except for the utter confusion surrounding whether we were going to wait for the arrival of a container of OBSs from SIO to be used on the next cruise, and exactly when that shipment was due to arrive. As it turned out, we sailed out of the harbor past an arriving container ship carrying the OBSs. The lack of timely and accurate information from the Marine Office resulted in much uncertainty and confusion and was the main reason that that the ship left port 12 hours late. It is vital to keep the ship and the science party informed in situations such as that, so that they are ready to act on whatever decision is made.

The transit from Valparaiso to the field area (Figure 1) took ten days. During that time two potentially serious equipment problems arose, both involving the SGI computers. Suzanne O'Hara deserves much credit for her skill and perseverance in solving both problems prior to arrival in the survey area.

a)The first problem was that when the Hydrosweep system was started up, we were unable to capture and broadcast the data. Hydrosweep was able to get the navigation data from the broadcast, but it was not possible to capture the Hydrosweep output, even though it was being written to the Hydrosweep tape. This turned out to be the result of a combination of problems. The first was a disk problem with the SGI computer ("Olive") responsible for capturing the Hydrosweep data for broadcast. This was solved by swapping disks with the "spare" SGI ("Popeye"). However, the data could still not be captured. The problem turned out to be in the program which receives the Hydrosweep data. It was unable to assign a socket for data reception which hung all data loggers and prevented any data collection until 2000Z on August 3 when the problem was solved by rewriting the software to allow the computer to pick the first free port to bind. It is unclear why this problem suddenly appeared in software which had been successfully used for some time.

b) The second problem was that after the disk on "Popeye" (formerly on "Olive") was reinitialized as part of a repair effort, it would not come back up. Suzanne O'Hara was finally able to bring the computer back to life by patiently trying various combinations of procedures, . This was a potentially serious problem since "Popeye" is not really a "spare" computer, but is used to clean and edit the Hydrosweep data, a necessary step in ending up with an acceptable, let alone high quality, data set.

Both of the above problems occurred during the ten days of transit to the field area and were solved prior to beginning the survey. With the exception of the BGM-3 gravimeter, all equipment worked satisfactorily during the five weeks of the survey. The BGM-3 gravimeter has been known for some time (more than a year) to have an unusually high drift rate. During EW9105, an additional problem was encountered, which was that the data was exceptionally noisy. Much of the noise was in the form of single point spikes, which could have be removed except for the fact that there were many hundreds of such spikes per day. As a result, the BGM-3 data was basically useless. Fortunately, the KSS-30 meter appears to have been working well. However, it needs to be pointed out that our present dependence on the KSS-30 brings up not only the potential, but the inevitability, of a very real fiasco down the road. The BGM-3, for which we have a full set of spares, has a sick sensor. The KSS-30 is working well, but we presently do not have a spare gyro for it and the cost of KSS-30 gyros is prohibitive ($50k - $70k). This has been the case for the past year and we have fortunately gotten away with gambling that the gyro will not fail. However, this can not continue indefinitely and we need to commit ourselves to one meter (my selection would be the BGM-3) and spend the money to make it viable. It costs the same amount to repair the BGM-3 as it does to have adequate spare parts for the KSS-30.

The survey was laid out as a series of 60 lines oriented along flow lines and spaced at 5 km intervals (See Figure 2). The survey area was approached from the ESE along a continuation of line 40, located at the center of the major ridge segment . Lines were then run to the south until the southern end of the survey area (line 1) was reached. A tie-line was then run up to the western end of Line 17, which was extended to the WNW as the southern of John Goff's two long lines. Upon reaching the Anti-Bauer escarpment which marks the western boundary of crust created at the present EPR, we turned to the north and then returned to the survey area along the western continuation of Line 40 to form the northern Goff line. The survey was then continued to the north. This strategy allowed us to obtain a 900 km long profile along a flow line as the northern Goff profile and to make sure that the southern profile was definitely just to the north of the transform. After completion of the 60 ESE-WNW survey lines, three NNE-SSW tie lines were run, particularly to tie the gravity lines together but also as a check on the navigation as expressed in the bathymetry data.

Navigation during the cruise was almost exclusively GPS (average of over 23 hours/day) and only one approximately 40 km stretch was identified which will need to be adjusted during post-processing. The captain and mates deserve much praise for the quality of their navigation during the survey. They were able to maintain the desired lines to within 100 m over distances of more than 200 km.

Following completion of the survey and tie lines, there were four days of transit to Easter Island. This time was used to grid the Hydrosweep data and to produce maps of the entire survey area and of portions of it at various scales. Data collection continued until the the ship reached the Chilean (Easter Island) 200 mile limit.

Comments on Hydrosweep

The Hydrosweep system generally performed satisfactorily. The noise level is greater than in the Seabeam data that most users will be used to working with, but is much improved over earlier Hydrosweep cruises. There are two types of noise in the Hydrosweep data. the first is a general increase in roughness from the center toward the outer beams. We investigated noise levels as a function of beam number during the cruise and found that the noise increased from negligible for the center beam to an r.m.s. value of about 15 m for the outermost beams. Much of the increase in the noise occurs in the outer half of the beam. This type of noise is probably inherent in all wide swath multi-beam systems and Hydrosweep may simply be more "honest" by not smoothing the data prior to broadcasting it. This type of noise can be controlled by an appropriate smoothing scheme.

The second type of noise are artifacts that appear peculiar to Hydrosweep. "Augers" are the most obvious and spectacular form of artifact. However, they are not really a great problem, because they are much less common since new procedures were instituted following EW9103. They are also easily recognized and removed from the data. A more serious problem is that, in addition to augers, Hydrosweep produces more subtle artifacts that superficially resemble real features and are difficult to find and flag using automatic detection schemes. The outer few beams have a tendency to turn up or down, creating fictitious track parallel bathymetry which can appear convincingly real. In addition, beams 3-4 and 55-56 are very often 20-40 m low, creating subtle gutters along the edge of the track. There are also numerous "mini-augers" 40-150 m deep (also occasional anti-augers - positive artifacts of about the same size). These can be recognized and often removed during hand editing of the data because they are track parallel, last for several pings, and are in the same beam locations (commonly 18-22 and 38-42, occasionally 8-12 and 48-52) as mega-augers. A more difficult problem is presented by "sags", 40-100 m deep depressions which are 10-15 beams wide and generally located in beams 10-20 or 40-50. Generally all that can be done this type of artifact is to curse at it.

The changes introduced in the TVG settings in order to eliminate augers and cut down on other artifacts have resulted in the creation of at least one additional problem. this occurs when a seamount is crossed in a manner such that both the seamount slope and the seafloor at its base are within the swath. In this case, the gains on the console must be turned down to avoid clipping on the seamount. However, the lowered gain almost inevitably results in the creation of large artifacts on the normal seafloor at the foot of the seamount.

We used the transit to work out a system for cleaning and editing artifacts from the Hydrosweep data. The procedure worked out is a two-step process. The first step involves passing the data through a cleaning program. The program that we used is a modification of Dave Caress' "mbclean" program and uses a gradient criteria to detect bad depth measurements. The slope between each depth measurement and its eight nearest non-flagged neighbors is calculated and if it exceeds a set value (such as 30°) the one of the pair of measurements which is furthest from the mean of the nine values under consideration is flagged as bad. If the number of valid measurements in a given ping is reduced below a given number (such as 10) , the entire ping is declared bad. The second step is hand editing of the data using Dale Chayes "hsed" beam editor. This step is necessary because the cleaning program, although very good at eliminating "augers" and at locating and eliminating excessively noisy data, was not able to detect and eliminate some more subtle, but obvious, artifacts. It also tends to eliminate valid points from steep slopes at seamounts and fracture zone escarpments, which need to be unflagged. Since many of the remaining artifacts after the automatic cleaning are located in the outermost beams, we adopted a practice of routinely flagging the outer four beams on each side. This saved much labor in the editing process and did not seriously impede the survey. With our 5 km line spacings, we thus ended up with very slight gaps between the swaths rather than a 1 km overlap.

Scientific Results

The region mapped during the cruise consisted of the 150 km offset Wilkes transform and a 250 km length of the EPR extending north from the transform to about 7°S. Survey lines were run along flow lines (N108°E and N188°E) and were 220 km long from the transform to 8°S and 200 km long north of 8°S (Fig. 2). Gravity and magnetics data were also collected on all lines.

Preliminary observations concerning the bathymetric data can probably most easily be summarized by quoting two A.G.U. abstracts that were submitted while still at sea. The first abstract deals with the ridge axis and flanks to the south of the 7°12'S OSC, while the second deals with the transform.

Abstract #1:

A 72,000 square km area of the East Pacific Rise between 7°S and 9.7°S (140 mm/yr full spreading rate) was surveyed using the Hydrosweep system on R/V Ewing during August and September, 1991. Complete coverage of the EPR was obtained from the Wilkes Transform (150 km offset) to the 7.2°S overlapping spreading center, extending more than 100 km (~1.5 ma) from the axis on both sides.

The EPR axis north of the transform has a uniform first-order topographic expression, being about 400 m high, 20 km wide and at an absolute depth of about 2725 m. A wide axial high is well defined because the ridge flanks do not appear to subside for a distance of about 60 km off the axis, while a deepening trend is observed farther away. The detailed shape of the axial high, however, changes along strike. The axial high at the center of the ridge segment, at about 8°S, has a dome-like cross section and gentle slopes. South of the segment center (toward the Wilkes transform) the upper portion of the axial high becomes narrower and has steeper flanks than in the segment center. North of the segment center, the upper portion has a boxy cross-section, with a central depression and very steep flanks. The shape of the axial high appears to correlate with the roughness of the abyssal hills in the immediate vicinity of the axis. Blocky abyssal hills are found in the northern portion of the segment, where the axis has a blocky cross section, while the hills are smoother and have lower relief near the segment center.

On the ridge flanks, there are numerous seamounts, most of which form chains approximately oriented along flowlines. the amplitude of the the abyssal hill fabric on the flanks varies significantly both with distance from the axis and position along the segment. In particular, there are a number of very smooth areas (the largest being 20 km on each side) on the flanks that may correspond to large basalt flows.

Abstract #2:

During a Hydrosweep survey conducted on R/V Ewing from August to September, 1991, we obtained complete coverage of the Wilkes Transform (150 km offset) located at about 9°S on the EPR.

The active Wilkes Transform is composed of two parallel faults (W2 and W3), trending at about N105°E, which form a transform valley about 8 km wide. The depth of the valley floor is quite variable, and the relief of the transform valley ranges from about 1 km to practically zero. An apparently inactive fault (W1), whose morphologic expression is a series of ridges and troughs, is located about 15 km north of the presently active principal transform deformation zone. This fault trends N103°E and terminates about 110 km (1.6 Ma) west of the northern EPR axis. The W1 fault was apparently cut off when the northern EPR axis propagated southwards to link up with the W2 fault. This propagation event appears to have started at 1.6 Ma and lasted until 0.85 Ma.

The propagation event is documented in the topographic fabric of the crest and flanks of the ridge. The axis of the EPR sweeps in a broad arc over a distance of about 20 km from a trend about 14° away from the transform to a trend almost parallel to the transform at the intersection. The abyssal hills on the eastern flank (Nazca plate) record the shape of this arc in the past and show the southward propagation.

An area of disrupted morphology is found immediately north of the W2 scarp, on the western flank (Pacific plate) of the EPR. This area extends 65 km north of the transform between the EPR axis and the eastern termination of the W1 scarp. The most striking features in this area are two large valleys trending parallel to the ridge axis, about 15 km wide and 40 km long. The absolute depth of these valleys reaches 4200 m (1000-1500 m below the surrounding seafloor). Near the inside corner of the northern ridge-transform intersection, several blocks of apparently rotated abyssal hill fabric are observed.

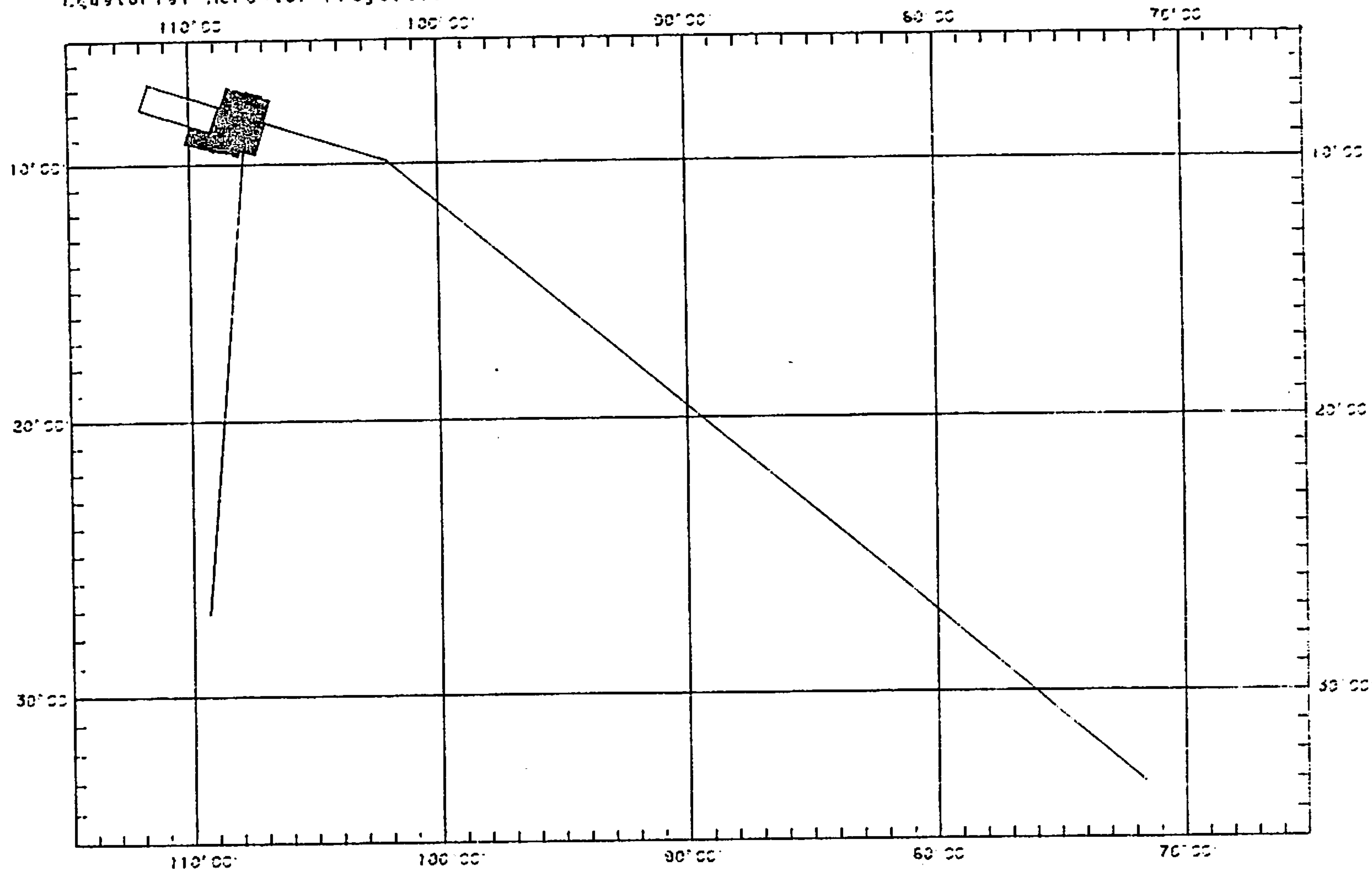
The A.G.U. abstract on the ridge axis and flanks did not discuss the overlapping spreading centers because we had not yet surveyed the 7°12'S OSC at the time when the abstracts had to be submitted. There are two OSCs in the survey area, at 8°36'S and at 7°12'S. The 8°36'S OSC has an extremely small offset (about 1 km) and can only generously be considered as an OSC. Although it is morphologically insignificant, a large volcanic ridge, 10 km wide, at places 1500 m above the surrounding seafloor and apparently consisting of coalesced seamounts, stretches away from it to the edge of the survey area on the Pacific plate. This ridge is oriented approximately along a flow line in both the relative (Pacific-Nazca) and absolute (hot spot) reference frames. It is also the only seamount chain on the Pacific plate which reaches closer than 40 km to the axis. The northern OSC at 7°12'S has an offset of about 6 km and generally resembles OSCs described in the literature except that the overlap basin is not particularly deep. It has a maximum depth of about 3200 m, approximately the same as the seafloor on either side of the axis. The 165 km-long ridge segment between the two OSCs has a nearly constant depth of about 2725 m, which varies by less than 10 m except at the very ends of the segment where it becomes deeper toward the OSCs.

Magnetic anomalies over the ridge axis and flank are generally of quite small amplitude (less than about 100 gammas) except over seamounts, and are difficult to correlate with the geomagnetic reversal sequence. This result was not unexpected due to the proximity of the field area to the equator. There is a dramatic increase in the amplitude of the magnetic anomalies at the latitude of the 7°12'S OSC which continues to the northern end of the survey area. The amplitude of the anomalies on lines 58 and 59 reaches 300-600 gammas. It is unclear whether the large amplitude anomalies continue to the north of the OSC. Amplitudes on line 60, our northernmost line are less than on those immediately over the OSC, but are still substantially greater than those on lines to the south. The large amplitude anomalies are found not only over the ridge axis, but continue to the eastern and western boundaries of the survey area. Thus, if the high amplitude magnetic anomalies are due to FeTi basalts erupted at the OSC, than the magnetics data suggests that the OSC has been located near its present position for 1.5 ma. Another large magnetic anomaly not associated with a seamount is located south of the 8°36'S OSC on the eastern (Nazca plate) ridge flank. This magnetic low appears abruptly on Line 27 at the latitude of the OSC and 50 km east of the axis. It continues to the south swinging in an arc toward the axis, which it reaches at profile 14 near the ridge-transform intersection. This anomaly, which has a maximum amplitude of over 1000 gammas, is not associated with any topographic feature.

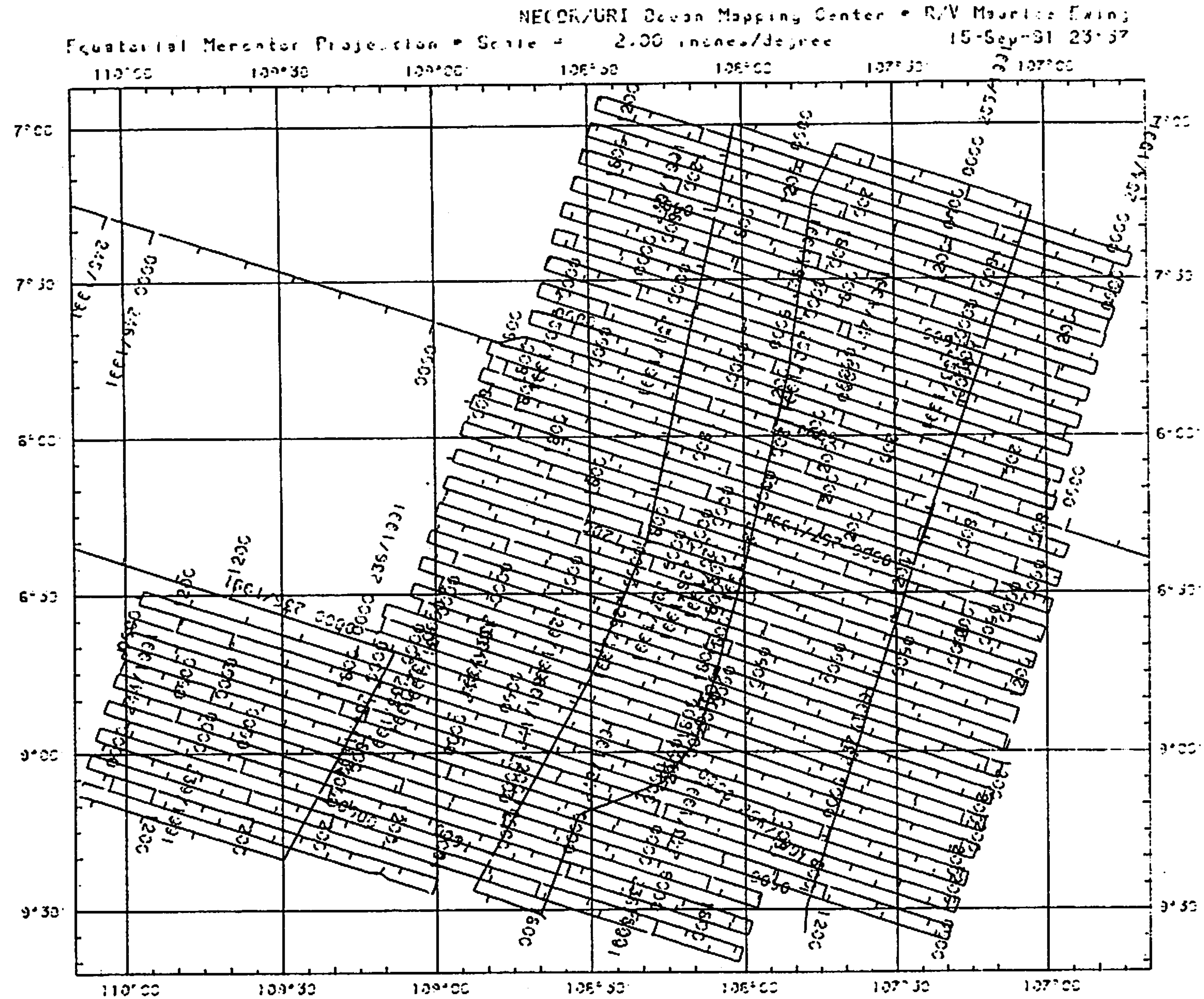
The KSS-30 gravity data appears to be of good quality, although the data is extremely noisy during periods of time when GPS was not available. The noise appears to have been introduced via the Eotvos correction and presumably will be removed during post-processing. The main features of the the gravity field are a 15-25 mGal gravity high over the ridge axis and gravity highs of up to 40 mGal over off-axis seamounts. The largest anomalies in the field area are associated with the two large N-S oriented valleys (rifts?) found north of the Wilkes transform on the Pacific plate. These are associated with negative gravity anomalies with a relative amplitude of greater than 50 mGal.

NECOR/URI Ocean Mapping Center * R/V Maurice Ewing
18-Sep-91 02:56

Equatorial Mercator Projection * Scale = 0.15 inches/degree



EW9105 - East Pacific Rise/Wilkes Fracture Zone
Valparaiso, Chile to Easter Island
01 August through 14 September 1991



EW9105 - Final Track Chart of Survey Area
JD 223-257 (01 August through 14 September 1991)